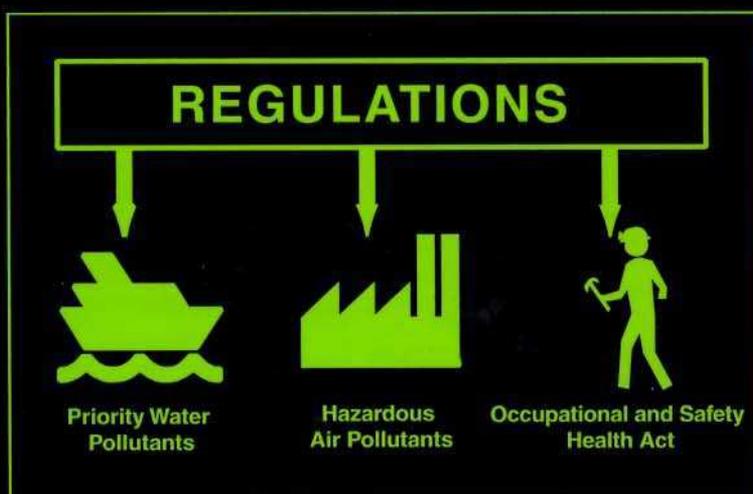


# REGULATORY CHEMICALS HANDBOOK



**Jennifer M. Spero**  
**Bella Devito**  
**Louis Theodore**

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To my family for their encouragement, help, love, and support.

Jennifer M. Spero

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To my Uncle Joe who has always given me encouragement and support.

Bella Devito

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To three Florida cohorts:

Ernie – my retired FBI hero

Richie – my basketball superstar male model

Mickey – my middleweight champion

Louis Theodore

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## PREFACE

As its title implies “Regulatory Chemicals Handbook” can be used to obtain detailed and pertinent reference information on the three major classes of regulated pollutants:

1. Hazardous Air Pollutants (HAPs)
2. Priority Water Pollutants (PWP)
3. Occupational, Safety, and Health Administration (OSHA) Chemicals

The requirement to treat and evaluate these regulated chemicals has led to the need for this handbook.

The book consists of numerous fields of information on each of the above mentioned regulated pollutants. We have presented as much information as possible in a 2-3 page section for each chemical. For example, the section on PWP contain 13 fields of information. These are listed below:

1. CAS # (Chemical Abstracts Service registry number)/DOT # (DOT identification):
2. Synonyms
3. Physical Properties
4. Chemical Properties
5. Biological Properties
6. Bioaccumulation
7. Origin/Industry Sources/Uses
8. Toxicity
9. Exposure Routes
10. Regulatory Status
11. Probable Fate
12. Treatability/Removability
13. Key References

A somewhat similar set of fields is provided for the HAPs and OSHA chemicals. Of particular value is the extensive information provided for Health Risk and Health Risk related areas. However, information in some of the fields was not available for a very few of the chemicals; this is indicated by the notation “not available.”

The reader should note that the chemical entries are listed by their names in alphabetical order. The HAP entries are listed in the order found in Section 112 under the 1990 Clean Air Act Amendments. Each entry is also listed in alphabetical order in Appendix A: Alphabetical List. The reader may use the alphabetical list in Appendix A to find a chemical. If the name of the chemical being sought cannot be found in Appendix A, the reader may employ the CAS Number Cross-Reference List in Appendix B to help locate the chemical.

For additional and more detailed information on the chemicals, the reader is directed to the list of references found under the heading Key References in the section entitled USING THIS BOOK and the field for the pollutant in question with the same heading.

We strongly recommend that the reader carefully review the USING THIS BOOK section before proceeding to use this Handbook. The useful information it contains about the organization and content of this reference text will help speed locating the chemical in question, assist in interpreting the data presented, and aid in quickly extracting the information required.

This is a handbook for all seasons, i.e., it has been written for both academic and professional use, and may be employed whenever and wherever information on these regulated pollutants is sought. It is a must for those working in the field and those involved peripherally with these chemicals.

Jennifer M. Spero  
Bella Devito  
Louis Theodore

## INTRODUCTION

There are three major classes of regulated chemicals: Hazardous Air Pollutants (HAPs), Priority Water Pollutants (PWP), and Occupational Safety and Health Administration (OSHA) Chemicals. These chemicals are of particular concern to both society and the technical community because of their somewhat unique properties and their (usually) adverse effect on our society and the environment. This handbook provides a wealth of information on each of these classes of chemical pollutants.

Before proceeding to the details of the specific chemicals, this INTRODUCTION familiarizes the reader to background material and the history of these three classes of regulated pollutants. The next three paragraphs provide this information.

Hazardous Air Pollutants (HAPs) were addressed in Section 112 of the 1977 amendments. That portion of the Act called on the EPA to create a list of hazardous air pollutants that would include any chemical substance that could produce serious health effects if present in the nation's air. The 1977 amendments further required that all hazardous air pollutants on the list be regulated so as to reduce their concentration in the air to a level that would protect the health of the public with "an ample margin of safety."

The Clean Water Act addresses a large number of issues of water pollution management. The control of industrial wastewaters is primarily the responsibility of the National Pollutant Discharge Elimination System (NPDES), originally established by Public Law 92-500. Any municipality or industry that discharges wastewater in the United States must obtain a discharge permit under the regulations set forth by the NPDES. Under this system, there are three classes of pollutants (conventional pollutants, priority pollutants, and nonconventional/nonpriority pollutants). Conventional pollutants are substances such as biochemical oxygen demand (BOD), suspended solids (SS), pH, oil and grease, and coliforms. Priority pollutants were so designated on a list of 129 substances originally set forth in a consent decree between the Environmental Protection Agency and several environmental organizations. This list was incorporated into the 1977 amendments and has since been reduced to 126 substances. Most of the substances on this list are organics, but it does include most of the heavy metals. These substances are generally considered to be toxic. However, the toxicity is not absolute; it primarily depends on the concentration. In recent years, pollution prevention programs have been implemented to reduce their use in industrial processes. This book addresses these priority (water) pollutants. The third class of pollutants could include any pollutant not in the first two categories. Examples of substances that are presently regulated in the third category are nitrogen, phosphorus, and sodium.

The Occupational Safety and Health Act (OSHA) of 1970 was passed by a bipartisan Congress "... to assure so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources." Under the Act, the Occupational Safety and Health Administration (OSHA) was created within the Department of Labor to:

1. Encourage employers and employees to reduce workplace hazards and to implement new or improve existing safety and health programs
2. Provide for research to develop innovative ways of dealing with occupational safety and health problems
3. Establish "separate but dependent responsibilities and rights" for employers and employees for the achievement of better safety and health conditions

4. Maintain a reporting and record keeping system to monitor job-related injuries and illnesses
5. Establish training programs to increase the number and competence of occupational safety and health personnel
6. Develop mandatory job safety and health standards and enforce them effectively
7. Provide for the development, analysis, evaluation and approval of state occupational safety and health programs

While OSHA continually reviews and redefines specific standards and practices, its basic purposes remain constant. OSHA strives to implement its mandate fully and firmly with fairness to all concerned. In all its procedures, from standards development through implementation and enforcement, OSHA guarantees employers and employees the right to be fully informed, to participate actively, and to appeal actions. Because of OSHA's policy regarding the need for workers to understand occupational dangers, management has established goals in order to implement training and communication programs that form the basis of support of its regulations. One such measure for achieving these goals was to compile a list of the chemicals determined to be potential hazards in the workplace. The original list of OSHA Chemicals has varied over the years as chemicals are added or deleted from the list. At the time of the preparation of this text, 453 chemicals were so noted by OSHA. Information on these chemicals is provided herein.

The heart of the book is, of course, the data and information provided in the various fields for each of the three classes of chemicals. The 188 HAPs are examined first; this is followed by the 126 PWP, which in turn is followed by the OSHA Chemicals. The Handbook concludes with an Appendix that is divided into two sections: A. Alphabetical List and B. CAS Number Cross-Reference List.

As noted in the Preface, we strongly recommend that the reader review the USING THIS BOOK section before proceeding to use this SDT Handbook.

Reasonable care has been taken to assure the accuracy of the information contained in the *Regulatory Chemicals Handbook*. However, the authors and the publisher cannot be responsible for errors or omissions in the information presented or for any consequences arising from the use of the information published in *Regulatory Chemicals Handbook*. Accordingly, reference to original sources is encouraged. The authors and the publisher strongly encourage all readers and users of chemicals, to follow the manufacturers' or suppliers' current instructions, technical bulletins, and material safety data sheets (MSDSs) for specific use, handling, and storage of all chemical materials. Reporting of any errors or omissions is solicited in order to assure that appropriate changes may be made in future editions.

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## USING THIS BOOK

The Spero, Devito, and Theodore (SDT) *Regulatory Chemicals Handbook* has been written for both academic and general professional use. It is intended for both technical individuals who work in environmentally related fields and for non-technical (in an environmental sense) individuals, such as office workers, secretaries, doctors, lawyers, etc. Last, but not least, it has been prepared for those consumers concerned about the environment. In effect, it is a reference guide containing information and data for each regulated chemical that may be used whenever and wherever information about these chemical pollutants is desired.

The book consists of numerous fields of information on each of the regulated chemicals "listed" under the general categories of Hazardous Air Pollutants (HAPs), Priority Water Pollutants (PWPs), and Occupational Safety and Health Administration (OSHA) Chemicals. Every attempt has been made to present as much information as possible in a 2-3 page setting. For a few of these chemicals, however, information in some of these fields was not available. This is indicated by the notation "NOT AVAILABLE." Specific fields for each of the three classes of regulated pollutants are provided below.

The fields of information for the HAPs are:

1. CAS # (Chemical Abstracts Service Registry Number)/DOT # (Dot Identification)
2. SYNONYMS
3. PHYSICAL PROPERTIES
4. CHEMICAL PROPERTIES
5. EXPOSURE ROUTES
6. HUMAN HEALTH RISKS
7. HAZARD RISK
8. MEASUREMENT METHODS
9. APPLICABLE REGULATIONS
10. MAJOR USES
11. STORAGE
12. FIRE FIGHTING
13. EXPOSURE GUIDELINES
14. PERSONAL PROTECTION
15. SPILL CLEAN UP
16. GENERAL COMMENTS
17. HEALTH SYMPTOMS
18. KEY REFERENCES

The reader should note that seventeen of the HAPs are categories or groups of compounds rather than single substances. Examples of these HAPs are Antimony Compounds, Coke Oven Emissions, Polycyclic Organic Matter and Radionuclides. For the HAPs that are the compounds of a specific element (such as Antimony Compounds), the properties of a few representative compounds as well as properties characteristic of the entire group are given. For the HAPs that are groups of compounds with very different properties, (such as Coke Oven Emissions), every effort was made to provide as much specific information as possible.

The fields of information for the PWP's are:

1. CAS # / DOT #
2. SYNONYMS
3. PHYSICAL PROPERTIES
4. CHEMICAL PROPERTIES
5. BIOLOGICAL PROPERTIES
6. BIOACCUMULATION
7. ORIGIN/INDUSTRY SOURCES/USES
8. TOXICITY
9. EXPOSURE ROUTES
10. REGULATORY STATUS
11. PROBABLE FATE
12. TREATABILITY/REMOVABILITY
13. KEY REFERENCES

The fields of information for the OSHA chemicals are:

1. CAS # / DOT #
2. SYNONYMS
3. PHYSICAL PROPERTIES
4. CHEMICAL PROPERTIES
5. EXPLOSION and FIRE CONCERNS
6. HEALTH SYMPTOMS
7. FIRST AID
8. HUMAN TOXICITY DATA
9. ACUTE HEALTH RISKS
10. CHRONIC HEALTH RISKS
11. EXPOSURE GUIDELINES
12. PERSONAL PROTECTION
13. SPILL CLEAN-UP
14. DISPOSAL AND STORAGE METHODS
15. REGULATORY INFORMATION
16. OTHER COMMENTS
17. KEY REFERENCES

The reader should note that chemical entries for the HAPs are listed by their names and in the alphabetical order used/appeared in the original applicable Act – with one exception. There are seventeen Hazardous Air Pollutants, including Antimony Compounds and Fine Mineral Fibers, which are categories or groups of chemicals for which no CAS number is available. These have been integrated into the alphabetical order rather than being grouped together at the end of the list as they appear in the 1990 Amendments to the Clean Air Act. Also, numbers, letters (such as N or n), Greek letters, and prefixes such as sym, tris, ortho, meta, and para that precede the name, do not affect the alphabetical order. It is also important to check the alphabetical order carefully as the use of two words for a name rather than one word could affect its location.

Names consisting of two or more words come before one word names. For example, methylene diphenyl diisocyanate comes before 4-4'methylenedianiline. The chemical entries for the PWP's and the OSHA Chemicals are also listed in alphabetical order, but do not reflect the appearance in the original act. The alphabetical list of the names of the regulated chemicals can be found in Appendix A. It is suggested that the reader employ the CAS number cross-reference List in Appendix B to locate the chemical. If the CAS number is not shown, two good sources for locating synonyms and their corresponding CAS numbers are: 1. Sax's Dangerous Properties of Industrial Metals, Richard J. Lewis, Van Nostrand Reinhold, 9th edition, 1996 (in 3 volumes) and 2. Suspect Chemicals Sourcebook, Roytech Publications, Bethesda, Maryland, 1996 edition.

The CAS number cross-reference list can be found in Appendix B. It provides the names of the regulated chemical entries in CAS number order. The CAS number follows the form XXXX-XX-X. The field on the left has a variable number of digits. The middle field always has two digits and the field at the right, one digit. The numbers are ordered first by the field at the left, second by the middle field and last by the field at the right. For more about CAS numbers, see the explanation of the CAS # field below.

## FIELDS OF INFORMATION

The various fields of information provided in the body of the handbook for each chemical are listed and explained below.

### CAS #

This is the Chemical Abstracts Service registry number. The CAS number is a unique number assigned to each substance by the Chemical Abstracts Service of the American Chemical Society. It definitively identifies the substance regardless of how it is named or how its formula is written. No two substances have the same CAS #. HAPs such as Nickel Compounds and Fine Mineral Fibers that are groups of substances do not have a specific CAS #. An example of a chemical CAS # is Fluorene; CAS # 86-73-7.

### DOT #

The United States Department of Transportation (DOT) identification number is a four-digit hazard code that is particular to a chemical's enlistment in the Hazardous Materials Table in the DOT regulations. This four-digit number must be used on transport documents, labels, packages, freight containers, tank vessels, etc., since it is used to determine the regulations for shipping a specific substance or material. The numbers or codes are preceded by "UN" or "NA." UN numbers are indicative of international shipments. NA numbers are recognized only in the United States and Canada. It should be noted, however, that many DOT numbers are not unique for specific substances.

## MOLECULAR FORMULA

The molecular formula indicates the number of atoms of each element in one molecule of the substance. For example, C<sub>18</sub>H<sub>12</sub> is the molecular formula of chrysene. Subscripts of 1 are understood to be present without being written.

## FORMULA WEIGHT

This represents the sum of the atomic weights of the atoms in the molecular formula. For example, 60.06 is the sum of the atomic weights of the two carbons, four hydrogens, and two oxygens in the chemical acetic acid,  $C_2H_4O_2$ .

## SYNONYMS

This field lists other names by which the chemical is known. Many of these names are trade names. The most commonly used synonyms are given. The following are examples of synonyms by which some chemicals are known: calcium carbonate is also known as agricultural limestone; 1,1,2-trichloroethane is also known as ethane trichloride or vinyl trichloride; and polychlorinated biphenyls are referred to as Aroclors. An exhaustive treatment of synonyms is not possible in a short information sheet.

## ORIGIN/INDUSTRY SOURCES/MAJOR USES

Special emphasis is given to two categories of use:

### Manufacture of other chemicals

A list of the materials and other chemicals manufactured with the use of this chemical. Generally, the pollutant is chemically changed by these manufacturing processes.

### Used as a component in the manufacturing process

A list of the ways the regulated pollutant is used in which it usually retains its chemical properties. The end product of which it may be part, however, will likely have properties that are significantly different from those of the original chemical.

## PHYSICAL PROPERTIES

These are properties that can be measured or observed without converting the chemical into a different substance. For example, boiling point temperature(s), density, specific heat, vapor pressures, and color may be determined without changing the chemical into a different substance.

## CHEMICAL PROPERTIES

These are properties whose measurement or observation requires converting the regulated pollutant into a different chemical substance. Some examples are: reactivity with air and/or water; reactivity with skin or metal; flash point temperature; and heat(s) of combustion.

The physical and chemical properties cited in the entries are in the form of abbreviations. The following table lists abbreviations that were used:

ABBREVIATION	PHYSICAL/CHEMICAL PROPERTY
AT	Auto-ignition temperature, °C or °F
BDN	Bulk density
BHN	Brinell hardness number, dimensionless
BP	Boiling point temperature at 1 atmosphere or 760 mmHg, °C, or °F
CLE	Coefficient of linear expansion
CP	Isobaric molar heat capacity, JK <sup>-1</sup> mol <sup>-1</sup>
CP (V)	Heat capacity at constant V
CP(P)	Heat capacity at constant P
CYT	Cytogenetic analysis
DE	Dissociation energy
DEC	Dielectric constant
DN	Density, g/mL or g/cm <sup>3</sup>
Dnd	DNA damage
DNI	DNA inhibition
Dns	Unscheduled DNA Synthesis
DR	Distillation Range
EC	Expansion coefficient
ER	Electrical resistance
FP	Flash point, °C or °F
FZP	Freezing point
HD	Heat of decomposition
H <sub>f</sub>	Molar enthalpy of fusion, kJ mol <sup>-1</sup>
HF	Standard molar enthalpy of combustion
HID	Heat of infinite dilution
HLA	HeLa Cell
HLC	Henry's law constant
HP	Heat of polymerization
HS	Molar enthalpy of sublimation, J mol <sup>-1</sup> or kJ mol <sup>-1</sup>
HV	Molar enthalpy of vaporization, kJ mol <sup>-1</sup>
IR	Index of refraction
LFL	Lower flammable limit in air, % by volume (at room temperature)
LP	Liquefaction pressure
LSG/S	Specific gravity at 68°F referenced to water at 39.2°F (4°C)
MEC	Minimum explosive concentration, g/m <sup>3</sup>
MMA	Microsomal mutagenicity assay
MP	Normal melting point temperature, °C or °F
MSC	Mutation in mammalian somatic cells
OT	Odor threshold, ppm or mg/m <sup>3</sup>
OTR	Oncongenic transformation
P <sub>c</sub>	Pressure at critical point, °C or °F
PP	Pour point, °C or °F
R Vapor/Air D	Relative density of vapor/air mixture
RS	Electrical resistivity, ohm-m or ohm-cm
SCE	Sister chromatid exchange
SSU	Saybolt universal seconds (SUS)
ST	Surface tension, mNm <sup>-1</sup> or dyne cm <sup>-1</sup>
SV	Specific volume
T <sub>c</sub>	Temperature at critical point, °C or °F

ABBREVIATION	PHYSICAL/CHEMICAL PROPERTY
TC	Thermal conductivity
TS	Tensile strength
UFL	Upper flammable limit in air, % by volume (at room temperature)
VD	Relative density of gases, referenced to air = 1
VS	Viscosity, mPa-s (liquids), $\mu$ Pa-s (gases)

## BIOLOGICAL PROPERTIES

These are properties listed for the Priority Water Pollutants. This section includes descriptive information on the biodegradability of the chemical, including information on biological systems used, measurement methods, removals achieved, and rate of removal. Biodegradation is the degradation of chemicals via biological pathways. Microorganisms such as bacteria and fungus account for the majority of the biodegradation; however, some plants have also been identified that biodegrade chemicals. This section also includes the method by which a Priority Water Pollutant can be detected in water; these are primarily USEPA methods.

## BIOACCUMULATION

Some of the regulated priority water pollutants concentrate in biological tissues or in the fatty tissue of organisms. Bioaccumulation refers to the fact that the chemical is not broken down by the metabolism of an organism and it tends to remain in the body tissue for a long time (bioconcentrate). The Log of the Bioconcentration Factor (Log BCF) is used to describe the ratio between the concentration of a chemical in biota living in the river (e.g., fish) and the concentration in the surrounding water. The Bioconcentration Factor (BCF) can be estimated from  $K_{ow}$  or water solubility of the chemical.

## PROBABLE FATE

This source group is separated into several fate processes. They are: photolysis, oxidation, hydrolysis, volatilization, sorption, biological processes, and in some cases, other reactions/interactions. Photolysis is the chemical reaction either directly or indirectly mediated by light (photons). An example is the dechlorination of chlorinated organics. Oxidation involves the removal of electrons. Hydrolysis is the addition of water molecules to outer shells of compounds. Hydrolysis can destabilize chemicals and can cause them to form insoluble precipitates. Volatilization is the transfer from (aqueous) solutions to the atmosphere (vapors). Adsorption is the physical and/or chemical process in which a substance is accumulated at an interface between phases (e.g. solid to liquid). Biological processes include biodegradation, bioaccumulation, and biomagnification. Biodegradation and bioaccumulation were discussed in the previous sections. Biomagnification involves increasing concentrations up the food chain.

## TREATABILITY/REMOVABILITY

For each alternative standard treatment process for the Priority Water Pollutants, removal ranges and achievable concentrations for each priority water pollutant are presented in actual wastewater samples and in some cases in synthetic wastewater samples, where appropriate data are available.

## **HEALTH RISK / HUMAN HEALTH RISK**

For some regulated chemicals, HEALTH RISK is divided into several categories, including Exposure Guidelines. These guidelines, sometimes referred to as **Toxic Exposure Guidelines**, are intended to provide the limits of exposure below which those who work with the chemical will not suffer any adverse health affects. It is expected that the worker is in good health. These numbers add meaning to toxicity data.

NOTE: Use of a respirator to reduce exposure to a HAP to below the Toxic Exposure Guideline requires professional expertise to determine the choice and effectiveness of the respirator. The use of a respirator can place strain on respiratory and cardiac systems. A medical exam by a specially trained health professional is needed prior to the use of a respirator to determine if the use of a respirator poses a risk to the health of the wearer.

The **Toxic Exposure Guidelines** cited are:

### **ACGIH TLV TWA**

American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) Time Weighted Average (TWA). The ACGIH, a private organization, issues its TLV TWA's annually for approximately 600 airborne substances. The TLV is the concentration below which a healthy worker could be exposed for 8 hours/day, 5 days/week, for 20 years without developing any disease. Time Weighted Average means that the TLV could be exceeded for a time if it is balanced by a time of lower exposure. For each TLV TWA, a CEILING value places an upper limit on the concentration to which the worker can be exposed regardless of how much time is spent at concentrations below the TLV TWA. A short-term exposure limit (STEL) is a fifteen minute TWA exposure that should not be exceeded at any time during a workday. For example, the TLV TWA for the HAP carbon tetrachloride is 5 parts per million (ppm) with a STEL of 30 ppm.

### **OSHA PEL TWA**

Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PEL) Time Weighted Average (TWA). Similar to the ACGIH TLV TWA but issued as a regulation by OSHA to protect workers. PELs are published in Title 29 of the Code of Federal Regulations (CFR) Part 1900 Section 1000.

### **NIOSH REL TWA**

National Institute of Occupational Safety and Health (NIOSH) Recommended Exposure Limits (REL) Time Weighted Average (TWA). NIOSH is a government agency that conducts research and makes recommendations on occupational safety and health but does not issue regulations. The NIOSH REL TWA is similar to the ACGIH TLV TWA.

### **IDLH**

Immediately Dangerous to Life or Health. IDLH values are issued by NIOSH and reflect a concentration of a chemical that is likely to cause death or immediate or delayed permanent adverse effects. The IDLH is also the concentration of the chemical that could incapacitate a

worker and thus prevent escape from a contaminated area. As a margin of safety, IDLH values are based on the effects that might occur as a consequence of a 30 minute exposure. NIOSH cautions, however, that the worker exposed to the IDLH should not continue to work for the entire 30 minute period. Every effort should be made to exit immediately.

## TOXICITY DATA

This data usually reflects the results of animal testing. The table of relative acute toxicity criteria given below was published by the National Institute for Occupational Safety and Health (NIOSH) in the Registry of the Toxic Effects of Chemical Substances (RTECS) in 1967. It is widely used to interpret animal toxicity data. As the table below indicates, for animal toxicity data, the lower the number, the greater the toxicity. The measures of toxicity used in the table, LD50 and LC50, (and others) are explained in the section that follows the table.

<u>Rating</u>	<u>Keywords</u>	<u>LD50 Single Oral</u> <u>Dose*</u> <u>(mg/kg)</u>	<u>LC50 Inhalation</u> <u>Vapor</u> <u>Exposure* (ppm)</u>	<u>LD50 Skin**</u> <u>(mg/kg)</u>
4	Extremely hazardous	#1	#10	#5
3	Highly hazardous	50	100	43
2	Moderately hazardous	500	1000	340
1	Slightly hazardous	5,000	10,000	2,800
0	No significant hazard	>5,000	>10,000	>2,800

\* Rats, \*\* Rabbits

Data on animal toxicity usually lists the route of entry into the body (oral ingestion, inhalation, adsorption through the skin, etc.) first, followed by the test animal (mouse, rat, human, etc.), followed by the measure of toxicity. The most common measures of toxicity are:

### LD<sub>50</sub>

Lethal Dose 50%. The LD50 is the dose of the chemical that killed 50% of the test animals when administered by a route of entry other than inhalation. The dose of the chemical (usually solids or liquids) is given as mg/kg, which represents milligrams of chemical per kilogram of body weight of the test animal. The LD50 is expressed in this manner because more chemical is needed to kill a larger animal. The oral rat LD50 for the HAP calcium cyanamide, for example, is 159 mg/kg.

**LC<sub>50</sub>**

Lethal Concentration 50%. This is similar to LD50 except that the route of entry is inhalation. The concentrations of the inhaled chemicals (usually gasses) are expressed as parts per million (ppm) or milligrams per cubic meter (mg/m<sup>3</sup>).

**LDLo**

Lethal Dose Low. The lowest dose that killed any of the animals in the study when administered by a route of entry other than inhalation.

**LCLo**

Lethal Concentration Low. Same as LDLo except that the route of entry is inhalation.

**TDLo**

Toxic Dose Low. The lowest dose used in the study that caused any toxic effect (not just death) when administered by a route of entry other than inhalation.

**TCLo**

Toxic Concentration Low. Same as TDLo except that the route of entry is inhalation.

**EC<sub>50</sub>**

This is the median growth limit concentration causing a 50% growth reduction.

**Acute Risks**

These are the risks associated with short exposures to high concentrations.

**Chronic Risks**

These are the risks associated with long term exposures to low concentrations.

**EXPLOSION AND FIRE CONCERNS (HAZARD RISK)**

All risks other than health risks can be found in this field. These risks are most often accidents, fires, explosions, corrosive hazards and chemicals that are incompatible with the regulated chemical. The National Fire Protection Association (NFPA) ratings are given for those chemicals that have been rated by that private organization. The NFPA ratings use a scale of 0 to 4 where 0 represents no hazard and 4 represents extreme hazard. The NFPA ratings are primarily intended as a cautionary guide to fire fighters with a fire in an area where the rated chemical is stored.

## EXPOSURE ROUTES

In addition to the routes of entry into the body, the activity, environment, source, or occupation that results in exposure to the regulated chemical is given where available.

## APPLICABLE REGULATIONS / REGULATORY STATUS/INFORMATION

The PWP section of this book contain criteria to protect freshwater and saltwater aquatic life as well as human health. These criteria are taken from a variety of allowable concentration levels set forth by EPA including:

- The California List
- Regulatory levels in leachates from landfills
- Contaminant levels in drinking water
- National Primary and Secondary Drinking Water Regulations
- Primary drinking water standards
- State drinking water standards and guidelines

Some drinking water standards and guidelines are also set by international organizations.

Other Toxicity Indicators, standards, and guidelines include the following:

- the EPA estimate of the per million lifetime risk of cancer to the most exposed individual
- EPA's lifetime health advisory, which is the concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects over a lifetime of exposure with a margin of safety
- Maximum Contaminant Level Goal, which is the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety
- Maximum Contaminant Level (MCL), which is the maximum permissible level of a contaminant in water which is delivered to any user of a public water system
- USSR MAC, which is the USSR-UNEP/IRPTC project that has set maximum allowable concentration limits in drinking water

The following regulations can be found by code in both the HAP section and the OSHA section of this book. This field of information included for the HAP and OSHA entries lists the primary laws and citations of the Code of Federal Regulations (CFR) where the chemical is regulated as well as other regulations (i.e. OSHA, SUPERFUND, etc.) pertaining to the given pollutant. The following table lists the type of regulation cited and its respective code used in the HAPs and OSHA chemicals section of this handbook.

REGULATION	CODE USED IN ENTRIES
40 Code of Federal Regulations (CFR), Part xxx, 1995 Edition	40 CFR xxx
RCRA, 40CFR261.30: hazardous codes, A; B; C; D; E; and F, which represent corrosive waste (A); toxicity characteristic waste (B); acute hazardous waste (C); ignitable waste (D); reactive waste (E); and toxic waste (F) respectively	A; B; C; D; E; F
CERCLA & Superfund	C & Sf
Clean Air Act	CAA
CAA, Criteria pollutant (CP) under the Clean Air Act (CAA).	CA1
CAA, Title III: hazardous air pollutants.	CA2
Chemicals regulated by the State of California, April 1994	CAL
Clean Water Act	CWA
SDWA, 47FR9352: 83 contaminants required to be regulated under the SDWA of 1986	S1
SDWA, 53FR1896: list of contaminants removed and substituted	S2
SDWA, 55FR1470: SDWA priority list of drinking water contaminants	S3
SDWA, 40CFR141.11: MCL (maximum contaminant level) for inorganic chemicals	S11
SDWA, 40CFR141.12: MCL for organic chemicals	S12
SDWA, 40CFR141.13: MCL for turbidity	S13
SDWA, 40CFR141.15: MCL for radium-226, radium-228, and gross alpha particle radioactivity	S15
SDWA, 40CFR141.16: MCL for beta particle and photon radioactivity from man-made radionuclides	S16
SDWA, 40CFR141.23: inorganic chemical sampling and analytical requirements	S23
SDWA, 40CFR141.24: organic chemicals other than total trihalomethanes, sampling and analytical requirements	S24
SDWA, 40CFR141.32: public notification	S32
SDWA, 40CFR141.40.e: community water systems and non-transient, non-community water systems	S40-e
SDWA, 40CFR141.40.j: monitoring at the discretion of the state	S40-j
SDWA, 40CFR141.50(a): MCLG (maximum contaminant level goal) for organic contaminants	S50-a
SDWA, 40CFR141.50(b): MCLG (maximum contaminant level goal) for organic contaminants	S50-b
SDWA, 40CFR141.51: MCLG for inorganic contaminants	S51
SDWA, 40CFR141.61: MCL for organic chemicals	S61
SDWA, 40CFR141.62: MCL for inorganic chemicals	S62
SDWA, 40CFR141.80: general requirements	S80

REGULATION	CODE USED IN ENTRIES
SDWA, 40CFR141.82: description of corrosion control treatment requirement	S82
SDWA, 40CFR141.87: monitoring requirements for water quality parameters	S87
SDWA, 40CFR142.62: variances and exemptions from the maximum contaminant levels for organic and inorganic chemicals	S62
SDWA, 40CFR143.3: secondary maximum contaminant levels	S3'
SDWA, 40CFR148.10: waste specific prohibitions-solvent wastes	S10
Federal Register	FR
FIFRA, Federal Insecticide, Fungicide, and Rodenticide Act	FIFRA
FIFRA, 40CFR152.175: pesticides classified for restriction	F1
FIFRA, 40CFR180.102-1147: tolerances and exemptions from tolerances for pesticide chemicals in or on raw agricultural commodities	F2
FIFRA, 180.3(3): class of dithiocarbamates	F3
FIFRA, 180.3(4): class of chlorinated organic pesticide	F4
FIFRA, 180.3(5): class of cholinesterase-inhibiting pesticides	F5
FIFRA, 180.3(6): class of dinitrophenols	F6
FIFRA, 40CFR185: tolerances for pesticides in food	F7
FIFRA, 40CFR186: tolerances for pesticides in animal feeds	F8
RCRA, 40CFR261.24: toxicity characteristic (D waste) RCRA, 40 CFR302.4: designation of hazardous substances	Dxxx (D waste)
RCRA, 40CFR261.31: hazardous wastes from non-specific sources (or F waste) RCRA, 40CFR302.4: designation of hazardous substances	Fxxx (F waste)
RCRA, 40CFR261.32: hazardous wastes from specific sources (or K waste) RCRA, 40 CFR302.4: designation of hazardous substances	Kxxx (K waste)
RCRA, 40CFR258.40: design criteria for municipal solid waste landfill (MSWLF) under RCRA	R1
RCRA, 40CFR258-Appendix 1: constituents for detection monitoring for MSWLF	R2-xx
RCRA, 40CFR258-Appendix 2: list of hazardous inorganic and organic constituents	R3
RCRA, 40CFR261.33: discarded commercial chemical products, off-specification species, container residues, and spill residues thereof. 261.33.e. (P waste)	P (P waste)
RCRA, 40CFR261.33: discarded commercial chemical products, off-specification species, container residues, and spill residues thereof. 261.33.f. (U waste)	U (U waste)

REGULATION	CODE USED IN ENTRIES
RCRA, 40CFR261 Appendix 8: hazardous constituents, see also 40 CFR261.11	R4
RCRA, 40CFR264 Appendix 9: ground water monitoring chemicals list	R5
RCRA, 40CFR266 Appendix 4: reference air concentration.	R6
RCRA, 40CFR266 Appendix 5: risk specific doses	R7
RCRA, 40CFR266 Appendix 7: health based limits for exclusion of waste-derived residues	R8
RCRA, 40CFR266 Appendix 8: PICs found in stack effluents	R9
RCRA, Compounds that RCRA permit writers should consider requiring the RCRA waste incineration facilities to sample and analyze for conducting exposure assessments (EPA -94/4)	R10
RCRA, Additional compounds that RCRA permit writers may also want to include to require the RCRA waste incineration facilities to sample and analyze for conducting exposure assessments. (EPA-94/4)	R11
SUPERFUND, 40CFR302.4: designation of hazardous substances	Sf1
SUPERFUND, 40CFR355-AB: 40 CFR355-Appendix B: list of extremely hazardous substances and their threshold planning quantities	Sf2
SUPERFUND, 40CFR372.65: chemicals and chemical categories to which this part applies (CAS number listing)	Sf3
SUPERFUND, 40CFR372.65: chemicals and chemical categories to which this part applies (chemical categories in alphabetical order)	Sf4
SUPERFUND, 40CFR372.65: chemicals and chemical categories to which this part applies (under diisocyanates)	Sf5
SUPERFUND, 40CFR372.65: chemicals and chemical categories to which this part applies (under polycyclic aromatic compounds)	Sf6
CWA, 40CFR116.4: designation of hazardous substances	CW1
CWA, 40CFR117.3: determination of reportable quantities	CW2
WA, 40CFR401.15: toxic pollutants (identical to compounds in 40 CFR403 Appendix B)	CW3
CWA, 40CFR413.02: total toxic organics (TTOCs)	CW4
CWA, 40CFR423-Appendix A: 126 priority pollutants	CW5
TSCA, 11-Aminoundecanoic acid	T25
TSCA, Anthraquinone	T30
TSCA, P-tert-butylbenzoic acid (P-TBBA), p-tert-butyltolu (P-TBT) and p-tert-butylbenzaldehyde (P-TBB)	T3
TSCA, Chlorinated naphthalenes	T43
TSCA, Chlorinated terphenyl	T45
TSCA, Phosphonic acid, [1,2-ethanediyl-bis[nitrilobis-(methylene)]tetrakis-(EDTMPA) and its salts	T95

REGULATION	CODE USED IN ENTRIES
TSCA, Hexachloronorbomadiene	T102
TSCA, Hexafluoropropylene oxide	T104
TSCA, 4, 4' - methylenebis(2-chloroaniline)(MBOCA)	T175
TSCA, chemical substance matrix by CAS registry number and trade name matrix in alphabetical order	T225-a
TSCA, 40CFR712.30: chemical lists and reporting periods	T30
TSCA, 40CFR712.30d: chemical listed by reporting dates	T30-d
TSCA, 40CFR712.30.e: substances listed by categories	T30-e
TSCA, 40CFR712.30.e1: aldehydes	T30-e1
TSCA, 40CFR712.30.e2: alkyl-, chloro-, and hydroxy-methyl diary ethers	T30-e2
TSCA, 40CFR712.30-e3: alkyl phosphates	T30-e3
TSCA, 40CFR712.30.e4: brominated flame retardants	T30-e4
TSCA 40CFR712.30.e5: chloroalkyl phosphates	T30-e5
TSCA 40CFR712.30.e6: Cyanoacrylates	T30-e6
TSCA 40CFR712.30.e7: IRIS chemicals	T30-e7
TSCA 40CFR712.30.e8: isocyanates	T30-e8
TSCA 40CFR712.30.e9: methyl ethylene glycol ethers and esters	T30-e9
TSCA, 40CFR712.30.e10: OSHA chemicals in need of dermal absorption testing	T30-e10
TSCA 40CFR712.30.e11: Propylene glycol ethers and esters	T30-e11
TSCA 40CFR712.30.e12: siloxanes	T30-e12
TSCA 40CFR712.30.e13: substantially produced chemicals in need of subchronic tests	T30-e13
TSCA 40CFR712.30.e14: sulphones	T30-e14
TSCA 40CFR716.120.a-d: substances and listed mixtures to which this subpart (specific chemical listing applies)	T120.a-d
TSCA 40CFR716.120.a: list of substances	T120-a
TSCA 40CFR716.120.c: substances listed by categories	T120-c
TSCA, 40CFR716.120.c1: alkylepoxides, including all noncyclic aliphatic hydrocarbons with one or more epoxy functional TSCA groups	T120-c1
TSCA, 40CFR716.120.c2: alkylphthalates - all alkyl esters of 1,2-benzenedicarboxylic acid (ortho-phthalic acid)	T120-c2
TSCA, 40CFR716.120.c3: alkyltin compounds	T120-c3
TSCA 40CFR716.120.c4: aniline and chloro-, bromo-, and/or nitroanilines	T120-c4
TSCA, 40CFR716.120.c5: aryl phosphates-phosphate esters of phenol or of alkyl-substituted phenols. Triaryl and mixed alkyl and aryl esters are included but trialkyl esters are excluded	T120-c5
TSCA, 40CFR716.120.c6: asbestos-asbestiform varieties of chrysolite (serpentine); crocidolite (riebeckite); amosite TSCA, (cummingtonite-grunerte); anthophyllite; tremolite; and actino-	T120-c6

REGULATION	CODE USED IN ENTRIES
lite	
SCA, 40CFR716.120.c7: bisazobiphenyl dyes derived from benzidine and its congeners, ortho-toluidine (dimethylbenzidine) and dianisidine (dimethoxybenzidine)	T120-c7
TSCA, 40CFR716.120.c8: chlorinated benzenes, mono- di-, tri-, tetra-, and penta-	T120-c8
SCA, 40CFR716.120.c9: chlorinated naphthalene, chlorinated derivatives of naphthalene (empirical formula) C <sub>10</sub> H <sub>x</sub> Cl <sub>y</sub> where x+y = 8	T120-c9
TSCA 40CFR716.120.c10: chlorinated paraffins-chlorinated paraffin oils and chlorinated paraffin waxes, with chlorine content of 35% through 70% by weight	T120-c10
TSCA 40CFR716.120.c11: ethyltoluenes-ethyltoluene (mixed isomers) and the ortho (1,2-), meta (1,3-), and para (1,4-) isomers	T120-c11
TSCA, 40CFR716.120.c12: fluoroalkenes- general formula: C <sub>n</sub> H <sub>2n</sub> X <sub>f</sub> where n = 2 to 3 and X = 1 to 6	T120-c12
TSCA 40CFR716.120.c13: glycidol (oxiranemethanol and its derivatives)	T120-c13
TSCA 40CFR716.120.c14: halogenated alkyl epoxides-halogenated noncyclic aliphatic hydrocarbons with one or more epoxy functional groups	T120-c14
TSCA, 40CFR716.120.c15: phenylenediamines (benzenediamines) - all nitrogen unsubstituted phenylenediamine and their salts with zero to two substituents	T120-c15
TSCA, 40CFR716.120.d: listed members of categories	T120-d
TSCA, 40CFR716.120.d1: aldehydes	T120-d1
TSCA, 40CFR716.120.d2: alkyl-, chloro-, and hydroxy-methyl diary ethers	T120-d2
TSCA, 40CFR716.120.d3: alkyl phosphates	T120-d3
TSCA, 40CFR716.120.d4: brominated flame retardants	T120-d4
TSCA, 40CFR716.120.d5: chloralkyl phosphates	T120-d5
TSCA, 40CFR716.120.d6: Cyanoacrylates	T120-d6
TSCA, 40CFR716.120.d7: IRIS chemicals	T120-d7
TSCA, 40CFR716.120.d8: isocyanates	T120-d8
TSCA, 40CFR716.120.d9: Methyl ethylene glycol ethers and esters	T120-d9
TSCA, 40CFR716.120.d10: OSHA chemicals in need of dermal absorption testing	T120-d10
TSCA, 40CFR716.120.d11: Propylene glycol ethers and esters	T120-d11
TSCA, 40CFR716.120.d12: siloxanes	T120-d12
TSCA, 40CFR716.120.d13: substantially produced chemical in need of subchronic test	T120-d13
TSCA, 40CFR716.120.d14: sulphones	T120-d14

REGULATION	CODE USED IN ENTRIES
TSCA, 40CFR721.225-9975: subpart E-significant new uses of chemical substances	T225-9975
TSCA, 40CFR766: dibenzo-para-dioxins/dibenzofurans	T766
TSCA, 40CFR766: chemical substances for testing	T766-25
TSCA, 40CFR766: congeners and LOQs for which quantitation is required	T766-27
TSCA, 40CFR766.35: reporting requirements	T766-35
TSCA, 40CFR766.38: reporting on precursor chemical substances	T766-38
TSCA, 40CFR799: identification of specific chemical substance and mixture testing requirements	T799B
TSCA, 40CFR799.18: chemicals subject of test rules or consent orders for which the testing reimbursement has passed	T799-18
TSCA, 40CFR799.3300: unsubstituted phenylene-diamines	T799-3300
TSCA, 40CFR799.5000: testing consent orders for substances and mixtures with chemical abstract service registry numbers	T799-5000
TSCA, 40CFR799-5025: testing consent orders for mixtures without chemical abstracts service registry numbers	T799-5025
TSCA, 40CFR799.5055: hazardous waste constituents subject to testing	T799-5055
OSHA, 29CFR1910.1000 Table Z1: limits for air contaminants under the Occupational Safety and Health Act (OSHA)	A1
OSHA, 29CFR1910.1000 Table Z2: limits for air contaminants applicable for the transitional period and to the extent set forth in paragraph 19.10.1000 under the Occupational Safety and Health Act (OSHA)	A2
OSHA, 29CFR1910.1000 Table Z3: mineral dusts under the Occupational Safety and Health Act	A3
OSHA, 29CFR1910.1001-1048: OSHA specially regulated substances	A4
OSHA, 29CFR1910.119 Appendix A: list of highly hazardous chemicals, toxics, and reactives	A5

## FIREFIGHTING PROCEDURES

This section provides information on the most favorable method of attacking a fire involving a chemical. All recommendations pertain to manual firefighting. Since it is easily attainable in large quantities and possesses an immense cooling capability, water is the selected agent in most cases. The preference of application method, however, should be made with caution. It should be noted that careful consideration is necessary regarding the method and rate of application of the extinguishing agent in relation to the size and type of fire. The choice of the proper agent may also be highly influenced by the physical and chemical properties of the material involved.

## **SPILL CLEAN-UP**

Chemicals that are spilled or accidentally released may cause damage to the environment, as well as injury to one's health and property. It is quite imperative, therefore, that certain procedures be taken in order to prevent the release from continuing, to prevent further damage to the environment, and to minimize exposure to the general public and emergency personnel.

The recommendations pertaining to spill and leak procedures may apply to both large and small spills. In cases where the reportable quantity is exceeded, any spill or release must be reported to federal, state and local emergency response agencies. It should be emphasized, however, that the information provided in this document focuses on previous planning and clean-up procedures.

## **HEALTH SYMPTOMS**

The statements on potential symptoms of exposure are intended to clearly describe acute (short-term) health effects that may occur immediately or shortly after exposure to each chemical by inhalation, physical contact, eye and skin absorption, or ingestion. Delayed or permanent effects produced by acute exposure are also described.

However, in all cases where the likelihood of becoming sick from chemicals is possible or if one suspects they are becoming sick because of exposure to chemicals at the workplace, the user is encouraged to contact trained personnel at suitable industrial health services to obtain more comprehensive information.

## **FIRST AID**

These guidelines set forth general emergency procedures for inhalation, eye and skin contact, and ingestion of toxic chemicals. However, prior to administration of an antidote or performance of other invasive procedures, one should obtain authorization and/or further instruction from the local hospital. It is imperative that care of persons exposed to toxic chemicals be conducted by a qualified physician or other recognized authority.

## **MEASUREMENT METHODS**

This field provides a brief description of the suggested monitoring and analysis method for quantitative determination of a particular substance. For example, a method for quantitative determination has been developed for cadmium, copper, manganese, and lead in water by means of co-precipitation with zirconium hydroxide followed by subsequent analysis by atomic adsorption spectrometry. An Inductively Coupled Plasma-Atomic Emission Spectrophotometric method has been employed by the Environmental Protection Agency (EPA Method 200.7) for the determination of dissolved, suspended, or total elements in drinking water, surface water, and domestic and industrial wastewaters.

In comparison, nonmetallic sampling systems, which are used primarily for the collection of environmental materials, may employ continuous sampling drawing measured air volumes through filter paper, or dry deposition on filter paper protected from the rain.

Whatever the case may be, measurement methods provide a collection method and, a sample work-up, and a method of analysis.

## DISPOSAL AND STORAGE METHODS

Unusable by-products from many chemical and metal-processing operations may often need to be contained and disposed of as hazardous wastes. Therefore, it is generally advisable to contact the Department of Environmental Protection (or equivalent at the state or local level) or the regional office of the federal EPA for specific recommendations on proper disposal. In all cases, however, disposal should be in accordance with federal, state and local regulations.

Safe storage practices should be applied to various types of wastes. Storage procedures are intended to prevent incompatible materials from coming into direct contact with each other and to isolate such materials from sources of ignition, such as smoking and open flames. The chemical and physical properties of the materials, the quantities of the materials, and the packaging systems employed will determine the extent of isolation or separation. However, it is always advisable to seek the recommendations of the supplier to obtain more in-depth information concerning incompatible materials with which the chemical should not be stored.

## GENERAL / OTHER COMMENTS

This field provides a collection of any information that may be important but not located in other fields. The information in this field will vary with the properties of the regulated chemical.

## KEY REFERENCES

Sources of more detailed information on the regulated chemicals are given here. The following is a list of the most frequently cited sources of additional information.

1. ACGIH Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) for 1996. ACGIH. Cincinnati, Ohio.
2. Aldrich Chemical Company Catalog Handbook of Fine Chemicals. Aldrich Chemical Company. Milwaukee, Wisconsin. 1996-1997.
3. Merck Index. Susan Budavari, editor. Merck and Co. Whitehouse Station, New Jersey. 12th edition, 1996.
4. NIOSH Pocket Guide to Chemical Hazards. Centers for Disease Control and Prevention. Cincinnati, Ohio. June 1994.
5. Environmental Law Index to Chemicals. C.C. Lee, editor. Government Institutes, Inc. Rockville, Maryland. 1996 edition.
6. Sax's Dangerous Properties of Industrial Materials. Richard J. Lewis, Sr. Van Nostrand Reinhold. New York. 9th edition, 1996 (in 3 volumes).

7. Hawley's Condensed Chemical Dictionary. Richard J. Lewis, Sr. Van Nostrand Reinhold. New York. 13th edition, 1997.
8. CRC Handbook of Thermophysical and Thermochemical Data. David R. Lide and Henry V. Kehiaian. CRC Press, Inc. Boca Raton, Florida, 1994.
9. CRC Handbook of Chemistry and Physics. David R. Lide, editor in chief. CRC Press, Inc. Boca Raton, Florida. 77th edition, 1996-1997.
10. Fire Protection Guide to Hazardous Materials. National Fire Protection Association. Quincy, Massachusetts. 11th edition, 1994.
11. Environmental Contaminant Reference Databook, volume 1. Jan C. Prager. Van Nostrand Reinhold. New York. 1995.
12. Suspect Chemicals Sourcebook. Roytech Publications. Bethesda, Maryland. 1996.
13. Health Effects Notebook for Hazardous Air Pollutants. U.S. Environmental Protection Agency. December 1994.
14. Material Safety Data Sheets (MSDS). MSDS are produced by the companies that manufacture and sell a particular chemical.
15. Hazardous Substances Data Bank (HSDB) Fact Sheet.
16. Occupational Safety and Health Guidelines.
17. Technological Processes: Coke Oven Emissions.
18. U.S. Department of Labor, Occupational Safety and Health Administration, OSHA Computerized Information System (OCIS).
19. Rapid Guide to Hazardous Air Pollutants. Howard J. Beim, Jennifer M. Spero, and Louis Theodore. Van Nostrand Reinhold. New York. 1998.
20. Air Toxics and Risk Assessment. Edward J. Calabrese and Elaine Kenyon. Lewis Publishers, Inc. Michigan. 1991.
21. Handbook of Toxic and Hazardous Chemicals and Carcinogens. Marshall Sittig. Noyes Publications. Westwood, New Jersey. 3rd edition. 1991 (in 2 Volumes).
22. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Philip H. Howard. Lewis Publishers, Inc. Michigan. 1989 (volumes 1 through 5).
23. Treatability Manual. Volume I. Treatability Data. Office of Research and Development U.S. Environmental Protection Agency. Washington, D.C. July 1980.

24. Priority Toxic Pollutants, Health Impacts and Allowable Limits. Noyes Data Corporation. ed. Marshall Sittig. Park Ridge, New Jersey. 1980.

25. Handbook of Environmental Data on Organic Chemicals. K. Verscuren. Van Nostrand Reinhold. 1983.

26. Handbook of Environmental Degradation Rates. P. Howard, R. Boethling, W. Jarvis, W. Meylan, E. Michalenko. Lewis Publishers, Inc. 1991

27. EPA Fact Sheets. Internet address: <http://mail.odsnet/TRIFacts>

28. NTP Chemical Repository. Radian Corporation. Aug. 1991. Internet address: [http://ntp-dbneihhs.gov/NTP\\_Reports/NTP\\_Chem\\_H&S/NTP\\_Chem/Radian.html](http://ntp-dbneihhs.gov/NTP_Reports/NTP_Chem_H&S/NTP_Chem/Radian.html)

29. EPA Office of Groundwater and Drinking Water. Technical Drinking Water and Health Contaminant Specific Fact Sheets. Internet address: <http://www.epa.gov/OGWDW/dwh/t-VOC.html>

30. Spectrum Laboratories. Chemical Fact Sheet. Internet address: <http://www.speclab.com/company/chemicals.htm>

31. Agency for Toxic Substances and Disease Registry (ATSDR) ToxFAQs. US Department of Health and Human Services Public Health Service. Internet address: <http://www.atsdr.cdc.gov/tfacts35.html>

32. Substances in Integrated Risk Information System (IRIS). Main EPA Site. Internet address: <http://www.epa.gov/ngispgm3/iris/irisdat.htm>

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## **HAZARDOUS AIR POLLUTANTS (HAPS)**

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**ACETALDEHYDE (C<sub>2</sub>H<sub>4</sub>,44.06)****CAS/DOT #:** 75-07-0/UN1089**SYNONYMS:** Acetic aldehyde, ethanal, ethyl aldehyde.

**PHYSICAL PROPERTIES:** Colorless, mobile liquid; pungent, suffocating odor, but at dilute concentrations has a fruity, pleasant odor; miscible with water, alcohol, ether, benzene, gasoline, toluene, xylene, turpentine and acetone; leafy green taste; MP (-123.5°C, 189°F); BP (21°C, 68.7°F); DN (0.788 g/mL at 15°C); ST (21.2 mN/cm at 20°C); VS (0.02456 mP at 20°C); HV (136.0 cal/g, 5.69x10<sup>5</sup> J/kg); VD (1.52; VP 740 mm Hg at 20°C); OT (0.21 ppm, mg/m<sup>3</sup>)

**CHEMICAL PROPERTIES:** Reacts with oxidizers, halogens, amines, strong bases and acids; FP (-8°C, -36°F); LFL (4.0%); UFL (60.0%); AT (365°C).

**EXPOSURE ROUTES:** Inhalation (present in natural environment as a product of plant respiration, incomplete wood combustion in fireplaces and woodstoves, coffee roasting, burning of tobacco, vehicle exhaust fumes, coal refining and waste processing); absorption.

**HUMAN HEALTH RISKS:** Inhalation-human TCLo 134 ppm/30M; EPA cancer risk level 5E<sup>-4</sup> mg/m<sup>3</sup>; EPA Group B2: probable human carcinogen; Acute Risks: irritation of skin, eyes and upper respiratory tract; respiratory paralysis; erythema; coughing; pulmonary edema; necrosis. Chronic Risks: effects on liver, kidneys, lungs, blood and CNS; symptoms of chronic exposure resemble those of alcoholism.

**HAZARD RISK:** Highly flammable liquid; oxidizes readily in air to form unstable peroxides that may explode spontaneously; vapors are heavier than air and may travel to a source of ignition and flash back; Combustion may produce irritants and toxic gases; NFPA Code: H 3; F 4; R 2.

**MEASUREMENT METHODS:** XAD tube with a special coating added; toluene; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** F2; CAA; CW1.

**MAJOR USES:** Intermediate in the synthesis of other chemicals such as acetic acid, peracetic acid, pyridine, pyridine bases, chloral and glyoxal monomer for polyacetaldehyde and comonomer for copolymers and ester production; synthetic flavor and adjuvant; manufacture of synthetic resins, dyes, paraldehyde, perfumes, aniline dyes, plastics, synthetic rubber, silvering mirrors, hardening gelatin fibers.

**STORAGE:** Keep in a cool, dry, well-ventilated location; separate from other reactive hazards.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100ppm; ACGIH STEL 150ppm; OSHA PEL TWA 200ppm (360 mg/m<sup>3</sup>); IDLH 2000ppm.

**PERSONAL PROTECTION:** wear special protective clothing and appropriate eye protection; positive pressure self-contained breathing apparatus is recommended at concentrations above the REL.

**SPILL CLEAN UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; control runoff and isolate discharged material for proper disposal; eliminate all ignition sources.

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 661 mg/kg; First aid: flush skin with water; remove to fresh air and give artificial respiration if necessary; remove contaminated clothing; if swallowed, wash out mouth with water if person is conscious.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); skin absorption (respiratory system, narcosis, nausea, loss of consciousness).

**KEY REFERENCES:** 4; 5; 6; 7; 10; 11; 12; 16.

### ACETAMIDE (C<sub>2</sub>H<sub>5</sub>NO, 59.07)

**CAS/DOT #:** 60-35-5/UN not available

**SYNONYMS:** Acetic acid amide, acetimidic acid, ethanamide, methanecarboxamide.

**PHYSICAL PROPERTIES:** Odorless when pure, but frequently has a mousy odor; deliquescent hexagonal crystals; colorless crystals; BP (211°C); MP (82.3°C); VP (1mm Hg at 65°C); DN (0.9986 g/ml); OT (140-160 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** Decomposes in water; one gram dissolves in 0.5 ml water, 2ml alcohol, 6 ml pyridine; soluble in chloroform, glycerol and hot benzene; incompatible with strong oxidizers, strong acids, strong bases, metals and halogenated materials; FP (not available); LFL (not available); UFL (not available); AT (not available).

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure in the plastics and chemical industries.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, mucous membranes and upper respiratory tract, mild skin irritation; gastrointestinal effects; Chronic Risks: liver effects; may alter genetic material; may cause cancer or heritable genetic damage.

**HAZARD RISK:** Incompatible with strong oxidizing agents, strong acids, strong bases, strong reducing agents, metals and halogenated materials; dust can be an explosion hazard when exposed to heat or flame; toxic fumes of carbon monoxide, carbon dioxide; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** T120-b.

**MAJOR USES:** Solvent and wetting agent for many organic compounds; alcohol denaturant; plasticizer; stabilizer; cryoscopic agent; intermediate for melamine, thioacetamide, pesticides, pharmaceuticals, rubber chemicals and plastics.

**STORAGE:** Keep away from sources of ignition; store in a cool, dry, well ventilated area; keep away from oxidizing materials.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV 10 mg/m<sup>3</sup> (total dust containing no asbestos and 1% crystalline silica for Particulates Not Otherwise Classified (PNOC)); OSHA PEL 15 mg/m<sup>3</sup> (total dust), 5 mg/m<sup>3</sup> (respirable fraction); NIOSH REL not established; IDLH not determined.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area; remove all sources of ignition.

**SPILL CLEAN-UP:** Ventilate area of leak or spill; clean up spills in a manner that does not dispose dust into air; moisten with water in order to reduce airborne dust and prevent scattering; pick up spill for recovery or disposal and place in a closed container; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates respiratory tract); skin (mild irritation); eyes (severe irritation, corneal damage); ingestion (gastrointestinal disturbances, tumors of the liver).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 7000 mg/kg; Personal protection: wear self contained breathing apparatus and protective clothing; First aid: flush skin and eyes with large amounts of water; if inhaled, remove to fresh air and give artificial respiration if necessary; remove contaminated clothing; if swallowed, wash out mouth if person is conscious.

**KEY REFERENCES:** 14; 16.

### **ACETONITRILE (C<sub>2</sub>H<sub>3</sub>N, 41.06)**

**CAS/DOT #:** 75-05-8/UN1648

**SYNONYMS:** Cyanomethane, ethanenitrile, ethyl nitrile, methanecarbonitrile, methyl cyanide.

**PHYSICAL PROPERTIES:** Colorless, limpid liquid; aromatic odor; ether like odor; burning, sweetish taste; soluble in ethyl alcohol and water; will slowly degrade to cyanides; BP (81.6°C); MP (-5°C); VP (87 mm Hg at 24°C); SG (0.786 at 15°C); VD (1.41); VS (0.35 cP at 20°C); OT (70.0 mg/m<sup>3</sup>); ST (29.04 dynes/cm at 20°C); HV (174 cal/g)

**CHEMICAL PROPERTIES:** Toxic vapors generated when heated; contact with strong oxidizers may cause explosions; dissolves somewhat in inorganic salts; liquid form will attack some forms of plastics, rubber and coatings; HC (-420 cal/g); FP (5°C, 42°F); AT (522°C, 973°F); LFL (4.4%); UFL (16%).

**EXPOSURE ROUTES:** Inhalation (manufacturing and industrial facilities, automobile exhaust and volatilization from aquatic environments, smoking tobacco or being near someone who is smoking); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TClO 570 mg/kg; EPA RfC 0.05 mg/m<sup>3</sup>; Acute Risks: irritation of mucous membranes; weakness; nausea; convulsions and death at concentrations higher than 500 ppm; Chronic Risks: effects on liver, kidneys and CNS; cyanide poisoning including headaches, numbness and tremors; dermatitis.

**HAZARD RISK:** Potential release of toxic vapors and solutions pose a threat to public safety; flammable; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; ethyl acetate; benzene; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** T120-d; F2.

**MAJOR USES:** Solvent in the manufacture of pharmaceuticals; used for spinning fibers, casting and molding plastic materials used in lithium batteries; used in the extraction of fatty acids from animal and vegetable oils; used in chemical laboratories for the detection of materials such as pesticide residues.

**STORAGE:** Handle and store under nitrogen; outside or detached storage is preferred, inside storage should be in a standard flammable liquids storage warehouse, room or cabinet.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2730 mg/kg; First aid: flush skin with large amounts of water; if inhaled, remove to fresh air and provide artificial respiration if necessary; remove contaminated clothing; if swallowed, wash mouth with water if person is conscious.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 40ppm; ACGIH STEL 60ppm; OSHA PEL TWA 40ppm (70 g/m<sup>3</sup>); OSHA STEL 60ppm; NIOSH REL TWA 20ppm (34 mg/m<sup>3</sup>); IDHL 500ppm.

**PERSONAL PROTECTION:** wear positive pressure self-contained breathing apparatus; wear impervious clothing, gloves, face shields, etc.; wear splash-proof safety goggles.

**SPILL CLEAN-UP:** remove all ignition sources; use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; absorb small quantities on paper towels; burn paper away from combustible materials; collect large quantities and atomize in suitable combustion chamber with appropriate effluent gas cleaning device.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, respiratory system); skin absorption (nausea, vomiting, chest pain).

**KEY REFERENCES:** 1; 3; 4; 5; 6; 7; 10; 14; 16.

**ACETOPHENONE (C<sub>2</sub>H<sub>8</sub>O, 120.16)**

**CAS/DOT #:** 98-96-2/UN not available

**SYNONYMS:** 1-phenylethanone, acetophenon, acetylbenzene, benzene acetyl, benzoyl methide, ethanone 1 phenyl.

**PHYSICAL PROPERTIES:** Monoclinic prisms or plates; slightly oily liquid; colorless liquid; liquid forms laminar crystals at low temperatures; sweet pungent odor of acacia; bitter aromatic flavor; soluble in alcohol, chloroform, ether, fatty oils, glycerol, acetone and benzene; BP (202°C); MP (20.5°C), VP (0.44 mm Hg at 25°C); VD (4.14); HV (11,371.5 gcal/gmole); ST (39.8 dynes at 20°C); VS (1.617°C at 25°C); OT (0.01-0.025 mg/m<sup>3</sup>); DN (1.03 g/ml).

**CHEMICAL PROPERTIES:** Stable under normal laboratory storage conditions; incompatible with strong oxidizing agents, strong bases and strong reducing agents; HC (991.6 kcal/g); FP (105°C, 221°F); AT (1058°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (contaminated air); ingestion (contaminated water); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: skin irritation and transient corneal injury, hematological effects, hypnotic or sedative effect, weakened pulse, congestion of the lungs, kidneys and liver; headaches; dizziness; unconsciousness; coughing; pulmonary edema; Chronic Risks: may cause reproductive and fetal effects.

**HAZARD RISK:** Combustible liquid; thermal decomposition and heating may produce irritating and toxic vapors; avoid areas where narcotic vapors may be concentrated; low potential BOD problem, may smother benthic life; incompatible with strong oxidizing agents, strong bases and strong reducing agents; decomposition emits carbon monoxide and carbon dioxide; NFPA Code: H 1; F 2; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** T120-b; T120-d; U waste; F2.

**MAJOR USES:** In perfumery for an orange odor; catalyst for polymerization of olefins; organic synthesis as a photosensitizer; solvent for plastics and resins; flavoring agent in foods, fragrance ingredient in soaps and detergents.

**STORAGE:** Keep away from heat, flame and sources of ignition; store in a cool, dry, well ventilated area.

**FIRE FIGHTING:** Use water, foam, carbon dioxide or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm; Short Term Exposure Limits (STEL) data not available; Permissible Exposure Limit (PEL) data not available; Recommended Exposure Limit (REL) data not available; IDLH data not available.

**PERSONAL PROTECTION:** Wear solvent-resistant gloves and clothing; Teflon® is recommended as a protective material; wear splash resistant goggles; enclose operations and use local exhaust ventilation at site of chemical release; use a NIOSH approved full facepiece respirator with an organic cartridge where the potential exists for exposure over 10 ppm; where the potential for high exposure exists, use self-contained breathing apparatus.

**SPILL CLEAN-UP:** Absorb liquids in dry earth, sand or vermiculite, and deposit in sealed containers; activated carbon or peat may also be used to absorb spills; ventilate area of spill after clean-up is complete; remove all ignition sources.

**HEALTH SYMPTOMS:** Inhalation (irritates nose and throat); skin (rash or burning feeling); eyes (burning sensation); ingestion (headache, dizziness, nausea, loss of coordination).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 815 mg/kg; First aid: flush eyes and skin with large amounts of water; if inhaled, remove to fresh air and provide artificial respiration if necessary; remove contaminated clothing; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 10; 14; 16.

## **2-ACETYLAMINOFLUORENE (C<sub>15</sub>H<sub>13</sub>NO, 223.29)**

**CAS/DOT #:** 53-96-3/UN not available

**SYNONYMS:** 2-acetamidofluorene, 2 acetaminofluorene, acetoaminofluorene, N-acetyl-2-aminofluorene.

**PHYSICAL PROPERTIES:** Tan, crystalline solid; MP (192-196°C); BP (not available); DN (not available).

**CHEMICAL PROPERTIES:** Stable under normal temperatures and pressures; incompatible with acids, acid anhydrides and oxidizing agents; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group 2B: probable human carcinogen; Acute Risks: no information on effects on humans; Chronic Risks: no information on effects on humans.

**HAZARD RISK:** Incompatible with acids, acid anhydrides and oxidizing agents; hazardous decomposition products are nitrogen oxides, carbon monoxide, carbon dioxide, hydrogen fluoride and nitrogen; NFPA Code: not available.

**MEASUREMENT METHODS:** None available.

**APPLICABLE REGULATIONS:** CA2; R4; R5; U005 (U waste); Sf1; A1.

**MAJOR USES:** Used in the laboratories of biochemists and technicians to study liver enzymes, the carcinogenesis of aromatic amines and the mutagenicity of aromatic enzymes.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use dry chemical, water spray or mist, chemical foam or alcohol resistant foam.

**EXPOSURE GUIDELINES:** NIOSH REL TWA use 29 CFR 1910.1014; OSHA PEL cancer suspect agent.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus; wear chemical safety goggles and other protective clothing.

**SPILL CLEAN-UP:** for small quantities, absorb on paper towels; for large quantities, may be absorbed on dry earth; cover with lime or soda ash; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin); skin absorption (reduced function of liver, kidneys, bladder, pancreas).

**GENERAL COMMENTS:** First aid: wash eyes with large amounts of water; wash skin with large amounts of soap and water; remove to fresh air and provide artificial respiration if necessary.

**KEY REFERENCES:** 4; 5; 12; 13; 14; 16.

### **ACROLEIN (C<sub>3</sub>H<sub>4</sub>O, 56.064)**

**CAS/DOT #:** 107-02-8/UN1092

**SYNONYMS:** Acquinite, acraldehyde, acroleine, acrylaldehyde, acrylic aldehyde, allyl aldehyde, aqualin, biocide.

**PHYSICAL PROPERTIES:** Colorless liquid; piercing disagreeable odor; soluble in water, ether and ethanol; miscible in benzene and acetone; MP (-87°C); BP (53°C); DN (0.8389 g/mL); VD (1.94; ST 24 dynes/cm at 20°C); HV (120 cal/g); OT (0.2 ppm); VP (214 mm Hg @ 20°C).

**CHEMICAL PROPERTIES:** Incompatible with amines, sulfur dioxide, metal salts, thiourea, dimethylamine, bases, oxidizers, reducing agents and oxygen; FP (-6°C); LFL (2.8%); UFL (31%); AT (219°C); HC (-6950 cal/g).

**EXPOSURE ROUTES:** Inhalation, ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA RfD (provisional) 0.02 mg/kg/d; Acute Risks: destructive to mucous membranes, upper respiratory tract, skin and eyes; burning sensation; coughing; wheezing; laryngitis; shortness of breath; headaches; nausea; Chronic Risks: upper respiratory tract infection; eye, nose and throat irritation; damage to cardiovascular system, liver, eyes and kidneys; carcinogen.

**HAZARD RISK:** Flammable; corrosive; sensitive to heat; may polymerize on exposure to light; combustion or decomposition production of carbon monoxide and/or carbon dioxide; vapors may travel long distances to source of ignition and flash back; NFPA Code: H 4; F 3; R 3.

**MEASUREMENT METHODS:** XAD tube; toluene; gas chromatograph with nitrogen/phosphorus detection.

**APPLICABLE REGULATIONS:** CAA; CWA; D waste; R5.

**MAJOR USES:** Manufacture of other chemicals; manufacture of pesticides, colloidal forms of metals, plastics, perfumes, glycerin, acrylic acid and esters.

**STORAGE:** Keep away from heat, sparks and open flame; keep container tightly closed.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1ppm; ACGIH STEL 0.3ppm; OSHA PEL TWA 0.1ppm (0.25 mg/m<sup>3</sup>); OSHA STEL 0.3ppm; NIOSH REL TWA 0.1ppm (0.25 mg/m<sup>3</sup>); NIOSH STEL 0.3ppm (0.8 mg/m<sup>3</sup>); IDLH 2ppm.

**PERSONAL PROTECTION:** wear clothing made of rubber, rubber safety shoes, and chemical resistant gloves; wear chemical safety goggles and face shield; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb small quantities on paper towels and evaporate in fume hood; burn the paper; for large quantities, cover with sodium bisulfite and flush with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes, skin and pulmonary edema); skin absorption (nausea, vomiting, respiratory system).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 26 mg/kg; First aid: wash eyes and skin immediately with large amounts of water for 15 minutes; remove to fresh air if inhaled and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 2; 3; 4; 5; 10; 14; 16

### **ACRYLAMIDE (C<sub>3</sub>H<sub>5</sub>NO, 71.08)**

**CAS/DOT #:** 79-06-1/UN2074

**SYNONYMS:** Acrylic amide, ethylenecarboxamide, propenamide, 2-propenamide, propenoic acid amide, vinyl amide.

**PHYSICAL PROPERTIES:** White crystalline chunks; odorless; soluble in ether, water, methanol, acetone, ethyl acetate, benzene and ethanol; MP (84.5°C); BP (125°C); DN (1.122 g/mL at 30°C); VD (2.45); VP (1.6 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Not flammable; air sensitive; may polymerize on exposure to light; FP (138°C); AT (424°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Ingestion; adsorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA RfD 0.0002 mg/kg/d; EPA cancer risk level 8E-7 mg/m<sup>3</sup>; EPA Group B2 probable human carcinogen; Acute Risks: eye and skin irritation; possible nervous system disturbances; drowsiness; incoordination; hallucinations; confusion; peripheral neuropathy; Chronic Risks: carcinogen; nerve damage; damage to cardiovascular system; reddish rash; adverse blood affects.

**HAZARD RISK:** Incompatible with bases, oxidizers, reducing agents, iron and iron salts, copper, aluminum, brass, free radical initiators; hazardous combustion products may include carbon monoxide, carbon dioxide, nitrogen oxides and/or ammonia; NFPA Code: H 2; F 2; R 2.

**MEASUREMENT METHODS:** Particulate filter/silica gel tube; methanol; gas chromatograph with nitrogen/phosphorus detection.

**APPLICABLE REGULATIONS:** CAA; C&Sf; D waste.

**MAJOR USES:** Production of polyacrylamide polymers; used as a chemical intermediate in the production of N-methylol acrylamide and N-butoxyacrylamide; absorbent in disposable diapers, medical products and agricultural products; sugar beet juice clarification; adhesives; printing ink emulsion stabilizers; thickening agents for agricultural sprays.

**STORAGE:** Store in a tightly closed container and keep in a dry place.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.03 mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.03 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.3 mg/m<sup>3</sup>; IDLH 60 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear positive pressure self-contained breathing apparatus; wear rubber gloves, boots, apron, etc.; wear chemical safety goggles.

**SPILL CLEAN-UP:** for small quantity, sweep onto paper, or other suitable material, place in appropriate container, and burn in safe place (such as fume hood); ventilate area; reclaim large quantities.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (central nervous system, tremors, hallucinations, paralysis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 124 mg/kg; First aid: wash eyes and skin with large amounts of water for 15 minutes; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 4; 5; 6; 10; 11; 14; 16; 17

### **ACRYLIC ACID (C<sub>3</sub>H<sub>4</sub>O<sub>2</sub>, 72.06)**

**CAS/DOT #:** 79-10-7/UN2218

**SYNONYMS:** Acroleic acid, ethylenecarboxylic acid, glacial acrylic acid, propene acid, propenoic acid, vinylformic acid.

**PHYSICAL PROPERTIES:** Colorless liquid, aromatic odor, acrid irritating, miscible in water, benzene, chloroform, ether and acetone; MP (14°C); BP (141.6°C); DN (1.0511g/mL at 20°C); ST (28 dynes/cm at 30°C); SG (1.051); VD (2.5); OT (1.04 ppm); VP (3.2 mm Hg at 20°C)

**CHEMICAL PROPERTIES:** Contributes to the production of photochemical smog; incompatible or reacts strongly with strong oxidizers and strong bases; FP (54°C, 130°F); LFL (2%); UFL (13.7%); AT (438°C, 820°F); HC (327.0 kcal/g at 25°C)

**EXPOSURE ROUTES:** Inhalation, ingestion, absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA RfD 0.08 mg/kg/d; Acute Risks: destructive to mucous membranes, upper respiratory tract, eyes and skin; burning sensation; coughing; wheezing; laryngitis; shortness of breath; headache; Chronic Risks: no information on effects on humans.

**HAZARD RISK:** Corrosive; decomposes to produce toxic fumes of carbon monoxide and carbon dioxide; flammable; combustible; may undergo exothermic polymerization; may become explosive if confined; NFPA Code: H 3; F 2; R 2.

**MEASUREMENT METHODS:** XAD tube; methanol/water; high pressure liquid chromatograph with UV detection.

**APPLICABLE REGULATIONS:** CA2; C&Sf; D waste.

**MAJOR USES:** Manufacture of other chemicals including acrylic esters, acrylic resins, superabsorbent polymers and detergents; oil treatment chemicals, water treatment chemicals and water absorbent polyacrylic acid polymers; polishes, paints, coatings, rug backings, adhesives and plastics.

**STORAGE:** Keep container tightly closed, keep away from heat or open flame, store in a cool dry place; do not refrigerate or freeze.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (5.9 mg/m<sup>3</sup>) (skin); OSAH PEL TWA (none); NIOSH REL TWA 2 ppm (6 mg/m<sup>3</sup>) (skin); IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious gloves, footwear, and clothing; wear splash-proof safety goggles; above the flash point, use a closed system of local exhaust ventilation; use explosion-proof electrical equipment; wear positive pressure self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; collect spilled liquid in sealable labelled containers or absorb in sand or inert absorbent; flush remaining spill with large amounts of water, but not into confined spaces such as sewers due to possibility of explosion.

**HEALTH SYMPTOMS:** Inhalation (cough, sore throat, burning sensation, shortness of breath, labored breathing) skin (redness, pain, blisters); eyes (redness, severe deep burns, loss of vision); ingestion (abdominal cramps, diarrhea, burning sensation, weakness, shock, loss of consciousness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 33,500 ug/kg; First aid: wash eyes and skin immediately with large amounts of water for 15 minutes; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 4; 10; 14; 16.

### **ACRYLONITRILE (C<sub>3</sub>H<sub>3</sub>N, 53.06)**

**CAS/DOT #:** 107-13-1/UN1093

**SYNONYMS:** Acritet, acrylon, acrylonitrile monomer, carbacryl, cyanoethylene, fumagrain, propenitrile, ventox, vinyl cyanide.

**PHYSICAL PROPERTIES:** Colorless liquid; can have a sweet odor; soluble in isopropyl alcohol, alcohol, ether, acetone, benzene; miscible with ethanol, carbon tetrachloride, ethyl

acetate, liquid carbon dioxide, toluene, petroleum ether and xylene; MP (-83°C); BP (77°C); DN (0.8004 g/mL); VD (1.83); ST (27.3 dynes/cm at 24°C); VS (0.34 cP at 25°C); HV (147 cal/g); OT (40.4 mg/m<sup>3</sup>); VP (100 mm Hg at 23°C)

**CHEMICAL PROPERTIES:** Incompatible with oxidizers, acids, bases, copper, copper alloys and heat; may polymerize from exposure to light; FP (32°F); LFL (3%); UFL (17%); AT (480°C, 897°F); HC (-7930 cal/g).

**EXPOSURE ROUTES:** Inhalation (cigarette smoke or automobile exhaust); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B1: probable human carcinogen; Acute Risks: destructive to mucous membranes, upper respiratory tract, eyes and skin; burning sensation; coughing; wheezing; laryngitis; shortness of breath; headache; nausea; vomiting; Chronic Risks: brain tumors; lung and bowel cancer.

**HAZARD RISK:** Highly flammable; corrosive; explosive; hazardous decomposition or combustion by-products include carbon monoxide, carbon dioxide, hydrogen cyanide and/or nitrogen oxides; vapors may travel long distances to source of ignition and flash back; NFPA Code: H 4; F 3; R 2.

**MEASUREMENT METHODS:** Charcoal tube; acetone/carbon disulfide; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CW1; CW5; D waste; R5; Sf2; Sf3; A1.

**MAJOR USES:** Manufacture of chemicals including acrylic fiber, plastics, rubber elastomers, plasticizers, solvents, polymeric materials, dyes, pharmaceuticals, insecticides and nylon; formation of high impact resins such as styrene acrylonitrile and acrylonitrile butadiene styrene.

**STORAGE:** Keep in a tightly closed container; keep away from heat, sparks or open flame; store in a cool, dry place; light sensitive.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2ppm (skin); OSHA PEL TWA 2ppm; OSHA (ceiling level) 10ppm/15M; NIOSH REL TWA 1ppm; NIOSH (ceiling level) 10ppm/15M; IDLH 85ppm.

**PERSONAL PROTECTION:** wear positive pressure self-contained breathing apparatus; wear rubber safety shoes, rubber gloves and aprons; wear chemical safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; remove solutions by vacuum cleaning to prevent an increase in airborne concentrations; releases may require isolation or evacuation; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (headache, sneezing, nausea, vomiting); ingestion (weakness, lightheadedness, abdominal pain).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 78 mg/kg; First aid: wash eyes and skin immediately with large amounts of water for 15 minutes; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 2; 4; 5; 6; 10; 16

**ALLYL CHLORIDE (C<sub>3</sub>H<sub>5</sub>Cl, 76.53)**

**CAS/DOT #:** 107-05-1/UN1100

**SYNONYMS:** Chlorallylene, chloroallylene, 3-chloroprene, 3-chloro-1-propene, 3 chloro-propylene, 2-propenyl chloride.

**PHYSICAL PROPERTIES:** Colorless to pale yellow liquid; garlic-onion odor; MP (-136.4°C); BP (44.6°C); DN (0.938 g/mL at 20°C); VP (362 mm Hg at 25°C); VD (2.64).

**CHEMICAL PROPERTIES:** Polymerization may occur upon heating or when in contact with acids or galvanized metals; incompatible with strong oxidizers, amines, metals and acids; FP (-36°C); AT (905°F); LFL (2.9%); UFL (11.2%).

**EXPOSURE ROUTES:** Inhalation (contaminated air); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA group C: possible human carcinogen; Acute Risks: irritation of eyes and respiratory passages; unconsciousness; corneal burn; conjunctivitis; death; numbness; headaches; dizziness; Chronic Risks: liver and kidney damage; effects the central nervous system; motor and sensory neurotoxic damage; pulmonary edema.

**HAZARD RISK:** Fire and explosion hazard when exposed to heat, flame or oxidizers; extremely flammable; vigorous or explosive reaction above -70°C with alkyl aluminum chlorides and aromatic hydrocarbons; violently exothermic polymerization reaction with Lewis acids and metals; NFPA Code: H 3; F 3; R 1.

**MEASUREMENT METHODS:** Charcoal tube; benzene; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; D waste; R5; Sf1; Sf3; CW1; CW2; A1; A5; CAL.

**MAJOR USES:** Used in the production of epichlorohydrin, glycerin, varnish, plastics, adhesives, perfumes, pharmaceuticals and insecticides; used in the synthesis of allyl compounds.

**STORAGE:** Keep in a cool place, away from heat; use adequate ventilation.

**FIRE FIGHTING:** Use carbon dioxide, alcohol foam or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm; ACGIH STEL 2ppm; OSHA PELTWA 1ppm; OSHA STEL 2ppm; DFG MAK 1ppm(3mg/m<sup>3</sup>); NIOSH REL TWA 1ppm.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus; wear protective clothing; chemical safety goggles, or gas mask if necessary.

**SPILL CLEAN UP:** remove all ignition sources; evacuate and cover area with activated carbon to absorb as much as possible; empty and deposit in sealed containers.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, unconsciousness, irritates eyes, nose and throat); skin absorption (local vasoconstriction, numbness); ingestion (burns, severe irritation of gastrointestinal tract).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 700 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 4; 5; 6; 8; 10; 16

#### **4-AMINOBIIPHENYL (C<sub>12</sub>H<sub>11</sub>N, 169.24)**

**CAS/DOT #:** 92-67-1/UN not available

**SYNONYMS:** 4-aminodiphenyl, p-aminobiphenyl, p-aminodiphenyl, biphenylamine, 4-phenylaniline, anilinobenzene, xenylamine.

**PHYSICAL PROPERTIES:** Colorless crystals; soluble in hot water, alcohol and chloroform; floral odor; volatile with steam; turns purple on exposure to air; MP (53°C, 125.6°F); BP (302.2°C, 576°F); SG (1.16); VP (1 mm Hg at 68°F)

**CHEMICAL PROPERTIES:** Oxidized by air; incompatible with acids, acid anhydrides, oxidizing agents; combustible solid but must be preheated before ignition; LFL (not available); UFL (not available); FP (153°C); AT (450°C, 842°F)

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: skin and eye irritation; irritation to upper respiratory tract and mucous membranes; cyanosis; headaches; dizziness; urinary burning; ataxia; Chronic Risks: bladder effects; may alter genetic material; suspected human carcinogen.

**HAZARD RISK:** Slight to moderate fire hazard when exposed to heat flames or strong oxidizers; decomposition emits toxic fumes of NO<sub>x</sub>; NFPA Code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter; silica gel tube; 2-propanol; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; R1; R4; R5; S3; A1; A4; CAL.

**MAJOR USES:** Sulfate detection; rubber antioxidant; organic research; cancer research; dye intermediate.

**STORAGE:** Keep separated from strong oxidants; keep container tightly closed.

**FIRE FIGHTING:** Use dry chemical foam, chemical powder, water spray or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA confirmed human carcinogen; OSHA PEL TWA potential occupational carcinogen; NIOSH REL TWA carcinogen; IDLH carcinogen, no level determined.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; enclose

operations and/or use local exhaust ventilation at site of chemical release; for extra personal protection, self-contained breathing apparatus is recommended; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable containers; use wet vacuuming or moisten first to prevent dusting; cover liquid spill with dry lime or soda ash; ventilate area and wash spill site after complete material pickup.

**HEALTH SYMPTOMS:** Inhalation (headache, dizziness, dullness, difficulty in breathing); skin absorption (weakness, muscular in coordination, methemoglobinemia); ingestion (urinary burning, blood in urine, hemorrhagic cystitis).

**GENERAL COMMENTS:** Oral rat LD50 500 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; remove contaminated clothing; if inhaled, remove to fresh air and provide artificial respiration if necessary.

**KEY REFERENCES:** 4; 5; 6; 14; 16.

### **ANILINE (C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub>, 93.14)**

**CAS/DOT #:** 62-53-3/UN1547

**SYNONYMS:** Aminobenzene, aminophen, benzenamine, phenylamine, aniline oil, benzamine, phenyl-amine.

**PHYSICAL PROPERTIES:** Colorless, oily liquid; aromatic odor; burning taste; Soluble in water, alcohol, ether and benzene; MP (-6.3°C); BP (185°C); SG (1.022); ST (44.1 dynes/cm at 10°C); VP (0.67 mm Hg at 25°C); VD (3.22); HV (198 Btu/lb); VS (4.423-4.435 cP at 20°C); OT (0.5 ppm)

**CHEMICAL PROPERTIES:** Stable but combustible; volatile with steam; polymerizes to a resinous mass, reacts vigorously with oxidizers; FP 158°F; AT 615°C; LFL 1.3%; UFL 11%; HC -14980 Btu/lb.

**EXPOSURE ROUTES:** Inhalation (contaminated air, tobacco smoke, burning of plastics); ingestion (corn, grains, rhubarb, apples, drinking water, animal feed, black tea); occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group B2: probable human carcinogen; Acute Risks: irritation of skin, eyes and upper respiratory tract; headaches; weakness; cyanosis; blue discoloration of fingertips, lips and nose; nausea; convulsions; Chronic Risks: insomnia; weight loss; skin lesions; malignant bladder growths; decrease in red blood cell count, hemoglobin levels and hematocrit.

**HAZARD RISK:** Combustible; reacts vigorously with oxidizing materials, fluorine, perchromates, acids; Ignites on contact with sodium peroxide and water; decomposition emits toxic fumes of NO<sub>x</sub>; NFPA Code: H 3; F 2; R 0.

**MEASUREMENT METHODS:** Silica gel tube; ethanol; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; R4; R5; R7; U012 (U waste); T799-18; A1; CAL.

**MAJOR USES:** Used in the production of resins, varnishes, perfumes, inks, paint removers, herbicides, whitening agents, artificial sweeteners; solvent.

**STORAGE:** Keep in a tightly closed container in a cool, dry, well ventilated area, away from sources of ignition and oxidizing agents.

**FIRE FIGHTING:** Use dry chemical, chemical foam, carbon dioxide or water spray.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm; ACGIH STEL 20mg/m<sup>3</sup>; OSHA PEL TWA 5 ppm (19 mg/m<sup>3</sup>); DFG MAK 2ppm (8mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear protective clothing, rubber gloves, rubber shoes, aprons, etc.; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb spilled aniline in vermiculite, dry sand, or earth, and properly dispose.

**HEALTH SYMPTOMS:** inhalation (irritation of respiratory tract, blue discoloration of fingertips, cheeks, nose, and lips, nausea, vomiting, headache, drowsiness, delirium, coma, shock); skin absorption (ataxia, dyspnea); ingestion (tachycardia, irritation of digestive tract).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 250 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide artificial respiration if necessary, if swallowed, give 2-4 cupfuls of milk or water.

**KEY REFERENCES:** 4; 5; 6; 10; 16

### **O-ANISIDINE (C<sub>7</sub>H<sub>8</sub>NO, 123.17)**

**CAS/DOT #:** 90-04-0/UN2431

**SYNONYMS:** o-aminoanisol, 2-anisidine, bezenamine, o-methoxyaniline, 1-amino-2-methoxybenzene, 2-methoxyaniline.

**PHYSICAL PROPERTIES:** Red or yellow, oily liquid; amine-like odor; insoluble in water; miscible with dilute mineral acid, alcohol, ether; MP (5-6°C, 40-42°F); BP (225°C, 437°F); DN (1.092 g/mL); VP (0.212 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Incompatible with strong oxidizers; volatile with steam; AT (437°C); FP (107°C); LFL (not available); UFL (not available)

**EXPOSURE ROUTES:** Inhalation (tobacco smoke); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin, mucous membranes and upper respiratory tract; cyanosis; headaches; dizziness; drowsiness; shortness of breath; rapid heart rate; methemoglobinemia; convulsions; Chronic Risks: allergic respiratory and skin reactions; carcinogen.

**HAZARD RISK:** Combustible; decomposition emits carbon monoxide, carbon dioxide, NO<sub>x</sub>; NFPA Code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** XAD tube; methanol; high pressure liquid chromatography with ultra violet detection.

**APPLICABLE REGULATIONS:** CA2; SF3; T30; CAL.

**MAJOR USES:** Used in the production of azo dyes and guaiacol.

**STORAGE:** Keep in a cool, dry area, away from heat and open flame; keep container tightly closed.

**FIRE FIGHTING:** Use dry chemical, foam, carbon dioxide or water spray.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>; OSHA PEL TWA 0.5 mg/m<sup>3</sup>; NIOSH REL TWA 0.5mg/m<sup>3</sup>; IDLH 50mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear chemical protective clothing which is specifically recommended by the manufacturer; wear dust- and splash-resistant safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb or cover with dry earth, sand or other non-combustible material; prevent entry into waterways, sewers, basements or confined areas; remove all ignition sources (no smoking, flares, sparks or flames in immediate area).

**HEALTH SYMPTOMS:** inhalation (headaches, dizziness, cyanosis); skin absorption (RBC Heinz bodies); ingestion (esophageal or gastrointestinal tract irritation).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2000 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; remove contaminated clothing; if swallowed, wash mouth if person is conscious.

**KEY REFERENCES:** 4; 5; 10; 14; 16

### **ANTIMONY COMPOUNDS (SBX, MW OF SB 121.75, FORMULA WEIGHT VARIES BY COMPOUND)**

**CAS/DOT #:** Sb: 7440-36-0/UN2871, varies by compound

**SYNONYMS:** Antimony, flowers of antimony, antimony oxide, antimony black, antimony peroxide, antimony white, diantimony trioxide, stibium.

**PHYSICAL PROPERTIES:** Of Sb: brittle silvery, white metal; insoluble in water; soluble in hot, concentrated sulfuric acid; MP (630°C); BP (1635°C); SG (6.684); HV (195100 J/mole); VP (1 mm Hg at 886°C)

**CHEMICAL PROPERTIES:** Of Sb: incompatible with strong oxidizers, strong acids, halogen acids, chlorine, fluorine; polymerization will not occur; slightly oxidized in air; FP (not available); AT (330°C); LFL (not available); UFL (not available)

**EXPOSURE ROUTES:** Inhalation (contaminated air near hazardous waste sites or antimony processing sites); ingestion (contaminated food and drinking water); absorption.

**HUMAN HEALTH RISKS:** EPA: high concern pollutant; Acute Risks: irritation of skin, eyes, lungs, membranes; stomach pain; vomiting; hair loss; rash; conjunctivitis; fatigue; Chronic Risks: chronic respiratory effects; heart muscle damage; dermatitis; nasal septum ulceration; disturbances in menstrual cycle.

**HAZARD RISK:** Moderate fire hazard in dust and vapor forms; reacts violently with halogens, oxidants, and acids; decomposition emits toxic fumes of  $\text{SbH}_3$ ; NFPA Code: not available.

**MEASUREMENT METHODS:** Particulate filter; acid; atomic absorption spectrometry.

**APPLICABLE REGULATIONS:** C&Sf; Sf3.

**MAJOR USES:** Used in the production of bullets, medicine, thermoelectric piles, lead storage batteries, sheet and pipe metal, paints, fireworks, paper, textiles and rubber.

**STORAGE:** Keep away from food.

**FIRE FIGHTING:** Use extinguishing media appropriate for surrounding fire.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $0.5 \text{ mg(Sb)/m}^3$ ; OSHA PEL TWA  $0.5(\text{Sb})\text{mg/m}^3$ ; NIOSH REL TWA  $0.5(\text{Sb})\text{mg/m}^3$ ; IDLH  $50\text{mg(Sb)/m}^3$ .

**PERSONAL PROTECTION:** wear appropriate chemical protective gloves, boots, and goggles; wear a filter mask or self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as fly ash or cement powder; do not use water on material itself and keep out of water sources and sewers.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes and lungs, stomach pain, diarrhea, vomiting, stomach ulcer); ingestion (vomiting, gastrointestinal upset).

**GENERAL COMMENTS:** Oral rat  $\text{LD}_{50}$   $7 \text{ g/kg}$ ; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 4; 5; 6; 11; 14; 16

### **ARSENIC COMPOUNDS (ASX, MW OF AS 74.92, FORMULA WEIGHT VARIES BY COMPOUNDS)**

**CAS/DOT #:** As: 7440-38-2/UN1558

**SYNONYMS:** Arsenicals, arsenic hydride, arseniuretted hydrogen, arsenic black, colloidal arsenic, metallic arsenic.

**PHYSICAL PROPERTIES:** Of As: Silvery to black, crystalline, amorphous metalloid; garlic odor when heated; insoluble in water; soluble in nitric acid: MP ( $814^\circ\text{C}$ ); BP (sublimes at  $613^\circ\text{C}$ ); VP (1 mm Hg at  $372^\circ\text{C}$ ); HV (11.2 kcal/gatom); SG (5.73).

**CHEMICAL PROPERTIES:** Reacts with nitric oxide and hydrochloric acid; semiconductor; darkens in moist air; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (volcanic debris, burning plywood, metal smelters); ingestion (fish and shellfish, contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA cancer risk level:  $2E-7$  mg/m<sup>3</sup>; EPA Group A: human carcinogen; Acute Risks: nausea; gastrointestinal effects; weakness; headaches; anemia; liver, kidney and blood effects; death; abdominal pain; CNS disorders; abnormal heart rhythm; leukopenia; jaundice; hemolytic anemia; hemoglobinuria; Chronic Risks: dermatitis; conjunctivitis; skin lesions; herpes; corns or warts; renal failure; pharyngitis; rhinitis; peripheral neuropathy; kidney or liver damage; bladder, liver, skin and lung cancer; tumors of the mouth esophagus, larynx and bladder.

**HAZARD RISK:** Risk of fire or explosion in the form of dust when exposed to heat or flame; flammable when combined with halogenated compounds; reacts vigorously with oxidizing materials; emits highly toxic fumes of arsenic; NFPA Code: not available

**MEASUREMENT METHODS:** Particulate filter; acid; atomic absorption spectrometry.

**APPLICABLE REGULATIONS:** C&Sf; D waste; CAL.

**MAJOR USES:** Used in the production of medicine, battery grids, cable sheaths, insecticides, rodenticides; radioactive tracer; wood preservation.

**STORAGE:** Keep in a cool, dry, well ventilated area.

**FIRE FIGHTING:** Allow arsine to burn itself out; use chemical powder, water spray, foam or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg(As)/m<sup>3</sup>; OSHA PEL TWA 0.01(As)mg/m<sup>3</sup>; NIOSH REL CL 2μg(As)/m<sup>3</sup>/15M; IDLH 5mg(As)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing (long-sleeved coveralls, boots, gloves, etc.); wear safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to "knock down" dust; use solvent extraction with high molecular-weight amines and quaternary ammonium compounds for the removal of arsenic from industrial effluents.

**HEALTH SYMPTOMS:** inhalation (sore throat and irritated lungs); skin contact (redness and swelling); ingestion (gastrointestinal effects, vomiting, diarrhea, shock).

**GENERAL COMMENTS:** Original NESHAP; Oral rat LD<sub>50</sub> 763 mg/kg; First aid: move victim to uncontaminated atmosphere; keep warm; provide respiration if necessary.

**KEY REFERENCES:** 4; 5; 6; 11; 14; 16

**ASBESTOS (MOST COMMON: MG<sub>6</sub>(SI<sub>4</sub>O<sub>10</sub>)(OH)<sub>8</sub>, MW NOT APPLICABLE)**

**CAS/DOT #:** 1332-21-4/UN2212(blue), UN2590 (white)

**SYNONYMS:** Chrysotile, amosite, crocidolite, tremolite, anthophyllite, actinolite, tremolite, actinolite, serpentine chrysotile, white asbestos, blue asbestos.

**PHYSICAL PROPERTIES:** A group of six different naturally occurring minerals; most common type is white; long, thin fibers similar to fiberglass; odorless; not volatile; not soluble; small fibers may occur in suspension in both air and water; MP (1112°F); BP (decomposes); SG (2.55 (white asbestos))

**CHEMICAL PROPERTIES:** Non-combustible; fire resistant fibers; FP (not available); AT (not available); LFL (not available); UFL (not available)

**EXPOSURE ROUTES:** Inhalation (contaminated air, asbestos related industries, erosion of asbestos bearing rocks, insulation, disintegration of asbestos roofing materials); ingestion (contaminated water, corrosion of asbestos cement pipes).

**HUMAN HEALTH RISKS:** Inhalation human TClO 1.2 fibers/cc; EPA cancer risk 4 fibers/cm<sup>3</sup>; EPA Group A: human carcinogen; Acute Risks: irritation of lungs Chronic Risks: pulmonary fibrosis; mesothelioma; lung disease- asbestosis; shortness of breath; coughing; pulmonary hypertension; lung, gastrointestinal, esophagus, stomach, intestinal and pharynx cancer.

**HAZARD RISK:** Material does not burn or burns with difficulty; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; acetone/triacetin; phase contrast microscopy.

**APPLICABLE REGULATIONS:** CA2; S1; S23; S32; S51; S62; Sf1; Sf3; CW3; CW5; T120-c6; A1; CAL.

**MAJOR USES:** Used in paper products, building materials, textiles, asbestos-cement products, gaskets, valves, clutch/transmission components, molten glass handling equipment, chemical tanks, electrical switchboards, cooling tower components, roofing compositions, packaging, pipes, ducts, floor tiles, reinforced plastics and rubber, insulation, paint filler, fireproof fabrics.

**STORAGE:** Keep in a tightly closed container.

**FIRE FIGHTING:** Material itself does not burn or burns with difficulty, use agent suitable for surrounding fire.

**EXPOSURE GUIDELINES:** ACGIH TLV 2 fibers>5µm/cm<sup>3</sup> (chrysotile and other forms of asbestos); ACGIH TLV 0.5 fibers>5µm/cm<sup>3</sup>; ACGIH TLV 0.1 fiber < 5µm/cm<sup>3</sup> (crocidolite); OSHA PEL 0.2 fibers> 5µm/cm<sup>3</sup>; NIOSH REL 0.1 fiber<5µm/cm<sup>3</sup>.

**PERSONAL PROTECTION:** wear an appropriate self-contained breathing apparatus with a full-facepiece.

**SPILL CLEAN-UP:** the concentration of asbestos fibers in drinking water can be removed by granular media filtration; asbestos cement pipes can be coated with a chemical precipitate to avoid the release of fibers from dissolution and leaching effects.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes and respiratory system).

**GENERAL COMMENTS:** Original NESHAP

**KEY REFERENCES:** 3; 4; 5; 6; 11; 14; 16

**BENZENE (C<sub>6</sub>H<sub>6</sub>, 78.12)**

**CAS/DOT #:** 71-43-2/UN1114

**SYNONYMS:** Annulene, benzol, benzole, coal naphtha, cyclohexatriene, pyrobenzol

**PHYSICAL PROPERTIES:** Clear, colorless liquid; negligible solubility in water; miscible with alcohol, ether, acetone, carbon tetrachloride; aromatic odor; MP (5.5°C, 41.9°F); BP (80°C, 176°F); DN (0.8787 g/ml at 15°C); ST (28.9 dynes/cm); VS (0.6468 mP at 20°C); VD (2.77); VP (1 mm at 36.7°C, 40 mm at 7.6°C, 400 mm at 60.6°C); OT (1.5 ppm, mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** Very stable; will not polymerize; reacts vigorously with strong oxidizing agents, sulfuric acid, nitric acid, chlorine, oxygen, ozone, permanganates, peroxides, perchlorates; FP (-11°C); LFL (1.3%); UFL (7.1%); AT (498°C, 928°F); HC (-9.698 cal/g)

**EXPOSURE ROUTES:** Inhalation (cigarette smoke, motor vehicle exhaust, evaporated gasoline, emissions from burning coal and oil); Ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Cancer Risk Level:  $1.0 \times 10^{-4}$  mg/m<sup>3</sup>; EPA Group A: known human carcinogen; Acute Risks: irritation of skin, eyes and upper respiratory tract; drowsiness; dizziness; headaches; death in high exposures; Chronic Risks: blood disorders; bone marrow disease; aplastic anemia; excessive bleeding; damage to immune system; chromosomal aberrations; menstrual disorders; leukemia.

**HAZARD RISK:** Dangerous fire hazard; explodes on contact with diborane, BrF<sub>5</sub>, permanganic acid; forms sensitive explosive mixtures with IF<sub>4</sub>, AGClO<sub>4</sub>, nitric acid, liquid O<sub>2</sub>; ignites on contact with sodium peroxide and water; incompatible or reacts strongly with strong oxidizers, many fluorides and perchlorates; NFPA Code H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide, gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** C2; d1; E50-a1; F62-1; H10; M1; M2-18; M3; R2; R3; R5; 46; 47; D018 (D waste); U019 (U waste); Reportable Quantity (RQ); S1; S3; W1; W3; A1; A2; CAL.

**MAJOR USES:** Manufacture of dyes, organic compounds, linoleum, varnishes, lacquers, resins, medicines; used in the manufacturing process of paint, coatings, adhesives, rubber, detergents, inks, paint thinners, tires, degreasing agents.

**STORAGE:** Outside storage preferred; inside should be in a standard flammable liquids storage room or cabinet.

**FIRE FIGHTING:** Use dry chemical, foam, or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (32 mg/m<sup>3</sup>); OSHA PEL TWA 1 ppm (3.19 mg/m<sup>3</sup>); OSHA PEL STEL 5 ppm; NIOSH REL TWA 0.1 ppm (0.32 mg/m<sup>3</sup>); NIOSH REL STEL 1 ppm; IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron, sleeves, or coveralls; wear splash-proof safety goggles or face shield; enclose operations and/or use local exhaust ventilation at the site of release; explosion-proof electrical equipment is required, as well as non-sparking handtools; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** collect leaking and spilled liquid in sealable containers or absorb as much as possible with inert materials, such as dry earth or sand; flush remaining liquid with large amounts of water but not into spaces such as sewers due to possibility of explosion; use water spray to disperse vapor; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, drowsiness, shortness of breath, nausea, convulsions, unconsciousness, irritates eyes, skin and nose); skin absorption (giddiness, staggered gait, fatigue, weakness, respiratory distress, headache, dizziness); contact (defatting of skin, dermatitis); ingestion (sore throat, abdominal pain, nausea, vomiting, bone marrow depression, aspiration into the lungs with risk of chemical pneumonitis).

**GENERAL COMMENTS:** Original NESHAP; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 14; 16

### **BENZIDINE (C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>, 184.26)**

**CAS/DOT #:** 92-87-5/UN1885

**SYNONYMS:** 4,4' bianiline, p-benzine, biphenyl-4,4'-diamine, fast cornith base B, p-diaminobiphenyl, 4,4'-diphenylnediamine.

**PHYSICAL PROPERTIES:** Grayish, yellow, white or slightly reddish crystal powder; insoluble in water; MP (117°C); BP (400°C); SG (1.25 at 68°F); DN (1.25 g/cm<sup>3</sup> at 20°C); VP (5E<sup>-4</sup> mm Hg at 25°C)

**CHEMICAL PROPERTIES:** Will darken when exposed to air or light; may be sublimed; forms insoluble salts with sulfuric acid; reacts violently with strong oxidizers, especially nitric acid; can be diazotized and oxidized; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (dust or mist); ingestion (contaminated water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TCl<sub>o</sub> 17600 ug/m<sup>3</sup>/14yr; EPA cancer risk level 2E-8 ug/m<sup>3</sup>; Acute Risks: cyanosis; mental confusion; vertigo; skin rashes; fatigue; headaches; nausea; possible heart attacks; skin irritation; Chronic Risks: bladder damage; affect on blood, liver, kidney and central nervous system; possible carcinogen.

**HAZARD RISK:** Flammable; emits toxic fumes under fire conditions; violent reaction with strong oxidants, especially nitric acid; sinks in water; can ignite be electric sparks; explo-

sion risk above flash point temperature; decomposes upon heating or burning producing toxic fumes including nitrogen oxides; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; silica gel; tube; reagent; high pressure liquid chromatography with ultraviolet detection.

**APPLICABLE REGULATIONS:** CA2; R4; R7; R8; Sf1; Sf3; CW3; CW4; CW5; A1; A4; CAL.

**MAJOR USES:** Manufacture of azo dyes, plastic films, rubber compounds; spray reagent for sugars; used for detection of hydrogen cyanide and sulfate; detection of blood stains.

**STORAGE:** Keep stored away from light and strong oxidants; store in a tightly closed container.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide, appropriate foam or water spray.

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 309 mg/kg; First aid: wash eyes with large amounts of water; wash skin with large amounts of soap and water; remove contaminated clothes; remove to fresh air and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA, confirmed human carcinogen; OSHA TWA, suspected occupational carcinogen; NIOSH TWA, potential human carcinogen.

**PERSONAL PROTECTION:** wear plastic overalls and butyl rubber gloves; use a gas-tight, fireproof suit; wear self-contained positive-pressure breathing apparatus; wear chemical safety goggles.

**SPILL CLEAN-UP:** cover the spill with a 9:1 mixture of sand and soda ash; isolate and remove discharged material but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (respiratory system, headache, nausea, dermatitis).

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16

### **BENZOTRICHLORIDE (C<sub>7</sub>H<sub>5</sub>CL<sub>3</sub>, 195.47)**

**CAS/DOT #:** 98-07-7/UN2226

**SYNONYMS:** Alpha-alpha-alpha-trichlorotoluene, benzenyl chloride, benzenyl trichloride, benzoic trichloride, phenylchloroform, phenyltrichloromethane.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; penetrating odor; MP (-7°C, 19.4°F); BP (219°C, 426 °F); SG (1.38); ST (38.03 mN/m at 20°C); VP(0.4137 mm HG at 25°C); HV (12169 kcal/kmol).

**CHEMICAL PROPERTIES:** Hydrolyzes in the presence of moisture; reacts with strong oxidizing agents; AT (210°C, 410°F); FP (97°C, 206.6°F); HC (3684 kJ/mole); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, mucous membranes and respiratory tract; headaches; abdominal cramping; nausea; diarrhea; Chronic Risks: weakness; mild leukopenia; anorexia; insomnia; liver function disturbances; tremors in the digits.

**HAZARD RISK:** Flammable; explosion risk above flash point; can ignite by electric sparks; reacts with water; decomposes on heating; emits toxic fumes under fire conditions; NFPA code: H 3; F 1; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; R4; P waste; Sf1; Sf2.

**MAJOR USES:** Manufacture of other chemicals including dyes, benzoyl chloride, chlorinated toluenes and benzotrifluoride.

**STORAGE:** Keep in a tightly closed container and store in a cool, dry area.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide or appropriate foam.

**SPILL CLEAN-UP:** Evacuate danger area; ventilate area of leak or spill; collect spilled liquid in sealable containers or absorb in dry sand or inert absorbent; flush remaining spill with large amounts of water, but not into confined spaces such as sewers due to possibility of explosion.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (not established); OSHA PEL (none); NIOSH REL (none); DFG MAK (confirmed human carcinogen).

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles or face shield, in combination with breathing protection; enclose operations and use local exhaust ventilation at site of chemical release; maintain eyewash baths and safety showers in work area.

**HEALTH SYMPTOMS:** inhalation (cough, sore throat, shortness of breath); skin (redness, burning sensation); eyes (redness, pain, severe deep burns); ingestion (abdominal pain, chemical pneumonitis, effects on liver, kidneys and thyroid).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 6 g/kg; First aid: flush eyes and skin with large amounts of water; remove contaminated clothing; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 4; 10; 14; 16.

### **BENZYL CHLORIDE (C<sub>7</sub>H<sub>7</sub>CL, 126.59)**

**CAS/DOT #:** 100-44-7/UN1738

**SYNONYMS:** Alpha chlortoluene, chloromethylbenzene, chlorophenylmethane, tolyl-chloride, alpha-tolyl-chloride.

**PHYSICAL PROPERTIES:** Colorless to slightly yellow; slightly soluble in ethanol, ethyl ether, chloroform and water; unpleasant, irritating odor; BP (179°C); MP (-47°C); OT (0.235 mg/m<sup>3</sup>); SG (1.10); ST (0.0375 N/m at 30°C); VP (1 mm Hg at 22°C); HV (70 cal/g).

**CHEMICAL PROPERTIES:** Fairly stable; stable during transport; reacts with steam and oxidizers; FP (74°C); HC (6700 cal/g); AT (585°C); LFL (1.1%); UFL (14%).

**EXPOSURE ROUTES:** Inhalation (contaminated air from floor tile manufacturers using butyl benzyl phthalate); absorption; ingestion; occupational exposure from production or use of dyes.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, mucous membranes and upper respiratory tract; severe skin burns; depression of central nervous system; weeping and twitching of eyelids; headaches; Chronic Risks: disturbances of liver functions; may cause cancer; may cause genetic damage; pulmonary edema; more susceptible to illness.

**HAZARD RISK:** Moderate fire hazard; reacts with water or steam to produce toxic and corrosive hydrochloric acid fumes; reacts violently with oxidizing material; releases heat or hydrochloric acid vapors when in contact with metals; NFPA code: H 3; F 2; R 1.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; CW1; CW2; T30-e; T120-d; A1; CAL.

**MAJOR USES:** Manufacture of other chemicals including benzyl compounds, synthetic tannins, dyes, perfumes, pharmaceutical products, fungicides, pesticides; used in manufacturing process of photographic developer, penicillin precursors, rubber accelerators, lubricants, plastics, odorants, plasticizers.

**STORAGE:** Keep in a tightly closed container; store in a cool, dry place; keep away from open flame.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide or appropriate foam; do not use water.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm; OSHA PEL TA 1ppm (5 mg/m<sup>3</sup>); NIOSH REL TWA 1ppm/15M; IDLH 10ppm.

**PERSONAL PROTECTION:** wear rubberized clothing and gloves; wear splash-proof goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** apply water spray or mist to knock down vapors; absorb in non-combustible material for proper disposal; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (coughing, burning of the throat, headache, dizziness, and weakness); skin absorption (severe burns, eye irritation); ingestion (nausea, vomiting, gastrointestinal damage).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1231 mg/kg; First aid: flush eyes and skin with large amounts of water; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 3; 4; 5; 10; 16

**BERYLLIUM COMPOUNDS (BEX, MW OF BE 9.0121, FORMULA WEIGHT VARIES BY COMPOUND)**

**CAS/DOT #:** Be: 7440-41-7/UN1566 (compounds), 1567 (powder)

**SYNONYMS:** Beryllium-9, metal powder, glucinum.

**PHYSICAL PROPERTIES:** Hard, brittle, gray-white solid; some compounds soluble in water; hard, brittle; high permeability to x-rays; soluble in acids and alkalis; MP (1278°C); BP (2970°C); DN (1.8477); VP (1 mm Hg at 1520°C)

**CHEMICAL PROPERTIES:** Resistant to oxidation at normal temperatures; high thermal conductivity; metal resistant to attack by acid due to the formation of a thin oxide film; HC (0.437 cal/g/°C at 30°C); FP (not available); AT (not available); LFL (not available); UFL(not available).

**EXPOSURE ROUTES:** Inhalation (dust in mining, fumes from burning of coal or fuel oil, tobacco smoke, flay ash through chimney stacks); Ingestion (contaminated fruits, vegetables and water); natural occurrence in soils.

**HUMAN HEALTH RISKS:** Inhalation human TCLo 300 mg/m<sup>3</sup>; EPA cancer risk 4E-7 mg/m<sup>3</sup>, EPA group B2: probable human carcinogen; Acute Risks: inflammation of lungs; acute pneumonitis; dermatitis; coughing; shortness of breath; weight loss; fatigue; Acute effects may be delayed: keep under medical observation; Chronic Risks: berylliosis; pulmonary granulomatous disease; anorexia; chronic pneumonitis; lung cancer; chronic skin ulcers; pulmonary edema; lung fibrosis.

**HAZARD RISK:** Non-combustible solid; moderate fire hazard in the form of powder; moderate fire hazard when exposed to flame or by spontaneous chemical reaction; incompatible with halocarbons; reacts incandescently with fluorine or chlorine; decomposition emits toxic fumes of beryllium oxide; reacts with strong acids and strong bases forming combustible gas; forms shock sensitive mixtures with some chlorinated solvents including carbon tetrachloride and trichloroethylene; NFPA code: H3; F1; R0.

**MEASUREMENT METHODS:** Particulate filter; acid; atomic absorption spectrometry; graphite furnace.

**APPLICABLE REGULATIONS:** Sf3.

**MAJOR USES:** Used as components in manufacture of electrical components, tools, aircraft, missiles, satellites, molds for plastics; used in consumer products such as televisions, calculators, x-ray machines, personal computers, mirrors.

**STORAGE:** Store in impervious containers; keep away from open flames, strong acids, strong bases and chlorinated solvents.

**FIRE FIGHTING:** Use sand for metal powder fires.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.002 mg/m<sup>3</sup>, suspected human carcinogen; OSHA PEL TWA 0.002 mg/m<sup>3</sup>, CL 0.005 mg/m<sup>3</sup>, Pk 0.025 mg/m<sup>3</sup>/30m; OSHA STEL 0.005 mg/m<sup>3</sup>; NIOSH REL TWA 0.005 mg/m<sup>3</sup>; IDLH 4mg (Be)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective outerwear; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** a high efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amount of carcinogen in exhausted air; contaminated materials can be placed in plastic bags for disposal.

**HEALTH SYMPTOMS:** inhalation (coughing, shortness of breath, acute or chronic lung disease); contact (dermatitis, acute conjunctivitis).

**GENERAL COMMENTS:** Original NESHAP; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 14; 16

### **BIPHENYL (C<sub>12</sub>H<sub>10</sub>, 154.22)**

**CAS/DOT#:** 92-52-4/UN not available

**SYNONYMS:** Bibenzene,1,1' biphenyl, lemonese, diphenyl, xenene, phenylbenzene, lemonese, xenene, diphenol.

**PHYSICAL PROPERTIES:** White scales; pleasant odor; colorless leaflets; negligible solubility in water; soluble in alcohol, ether, most organic solvents, benzene and methanol; MP (70°C, 158°F); BP (254°C, 489°F); SG (0.992); VP (9.46 mm Hg at 115°C).

**CHEMICAL PROPERTIES:** Incompatible with strong oxidizing agents; will not polymerize; stable under normal conditions; FP (113°C); LFL (0.6%); UFL (5.8%); AT (1004°C).

**EXPOSURE ROUTES:** Inhalation (diesel exhaust); ingestion (contaminated water, residue on fruits from packing paper); occupational exposure.

**HUMAN HEALTH RISKS:** EPA RfD 0.05 mg/kg/d; inhalation human TCL<sub>o</sub> 4400 ug/m<sup>3</sup>; Acute Risks: irritation to eyes, skin, mucous membranes and upper respiratory tract; nervous system disturbances; liver damage; nausea; headaches; vomiting; diarrhea; numbness; body aches; fatigue; Chronic Risks: mutagenic effects; target organs: liver, central nervous system, peripheral nervous system.

**HAZARD RISK:** Combustible solid; poisonous gases produced in fire; decomposition emits carbon dioxide and carbon monoxide; avoid contact with heat, flame, ignition sources and incompatible materials; NFPA code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; Sfl; TSCA.

**MAJOR USES:** Intermediate for polychlorinated biphenyls; organic synthesis; heat transfer agent; plant disease control; dyeing assistant for polyesters; manufacturing of benzidine; fungistat in packaging of citrus fruit.

**STORAGE:** Keep stored away from oxidizers; keep in a tightly closed container in a cool, dry well ventilated area; containers of this material may be hazardous when empty since they retain product residues (dust, solids).

**FIRE FIGHTING:** Use water spray, dry chemical, alcohol foam or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 ppm; OSHA PEL TWA 0.2 ppm (1mg/m<sup>3</sup>); NIOSH REL TWA 0.2 ppm (1mg/m<sup>3</sup>); IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear approved respiratory, chemical-resistant gloves, safety goggles, and other protective clothing.

**SPILL CLEAN-UP:** ventilate area of spill; collect powdered material in a safe manner and deposit in sealed containers; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); skin absorption (headache, nausea, fatigue, numbness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2400 mg/kg; First aid: flush eyes with large amounts of water for at least 15 minutes; wash skin immediately with large amounts of soap and water; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 10; 14; 16.

**BIS(2-ETHYLHEXYL)PHTHALATE (C<sub>6</sub>H<sub>4</sub>-1,2-[CO<sub>2</sub>CH<sub>2</sub>CH(C<sub>2</sub>H<sub>5</sub>)(CH<sub>2</sub>)<sub>3</sub>CH<sub>3</sub>]<sub>2</sub>, 390.62)**

**CAS/DOT #:** 117-81-7/UN not available

**SYNONYMS:** Di-sec octyl phthalate, BEHP, bisoflex-81, compound 889, ethylhexyl phthalate, flexol DOP, octoil.

**PHYSICAL PROPERTIES:** Colorless liquid; very little odor; MP (-50°C); BP (384°C); SG (0.981); VP (6.2E<sup>-8</sup> mm Hg at 25°C); VS (80 cP at 20°C).

**CHEMICAL PROPERTIES:** Stable under normal temperature and pressure; incompatible with strong oxidants; FP (199°C); AT (390°C); LFL (10%); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (air in a newly painted room, air in a room with newly installed flooring); Ingestion (contaminated water, residue on food from plastic storage containers); kidney dialysis; occupational exposure from factories that manufacture or use DEHP.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute Risks: gastrointestinal distress; skin and eye irritation; liver and kidney effects; adverse effects on weight gain and appetite; Chronic Risks: dermatitis.

**HAZARD RISK:** Irritating and toxic gases emitted during a fire; incompatible with strong oxidants; emits hazardous decomposition products of carbon dioxide, carbon monoxide and toxic gases; NFPA code: H 0; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter; carbon disulfide, gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; R3; R5; R9; Sfl; CW4; CW5; CAL.

**MAJOR USES:** Used in the production of polyvinyl chloride; added to plastics to make them flexible; liquid used in vacuum pumps.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use dry chemical, water spray or mist, chemical foam or alcohol resistant foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg/m<sup>3</sup>; ACGIH TLV STEL 10 mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; NIOSH REL STEL 10 mg/m<sup>3</sup> (potential occupational carcinogen); IDLH 5000 mg/m<sup>3</sup> (potential occupational carcinogen).

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; use self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; use self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**HEALTH SYMPTOMS:** Inhalation (cough, sore throat, irritates mucous membranes); skin (dermatitis); ingestion (effects on gastrointestinal tract, liver effects).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 30600 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide artificial respiration if necessary; remove contaminated clothing; if swallowed, rinse mouth with water if person is conscious.

**KEY REFERENCES:** 4; 5; 14; 16.

## **BIS(CHLORMETHYL)ETHER (C<sub>2</sub>H<sub>4</sub>CL<sub>2</sub>O, 114.96)**

**CAS/DOT #:** 542-88-1/UN 2249

**SYNONYMS:** BCME, chloro-methyl-ether, sym-dichloro-dimethyl-ether, oxybis(chloromethane).

**PHYSICAL PROPERTIES:** Colorless liquid; suffocating odor; miscible with alcohol, ether and organic solvents; MP (-41.5°C); BP (106°C); DN (1.323 g/ml); VP (30 mm Hg at 22°C); VD (4.0; SG 1.32).

**CHEMICAL PROPERTIES:** Volatile liquid; unstable in moist air; reacts with acids, water and rubber; attacks plastics; forms spontaneously from formaldehyde and chloride ions in moist air; FP(<19°C); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (workplace); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA group A: known human carcinogen; Acute Risks: irritation of skin, eyes, mucous membranes, respiratory tract and lungs; pulmonary congestion; dizziness; nausea; vomiting; sore throat; pulmonary edema; headaches; abdominal cramps; hem-

orrhage; Chronic Risks: chronic bronchitis; impaired respiratory function; lung edema; lung cancer.

**HAZARD RISK:** Flammable; dangerous fire hazard; explosion hazard with air mixtures of ether vapors; can form peroxide that detonate when heated; decomposes on heating and on contact with water, producing toxic and corrosive fumes of hydrogen chloride and formaldehyde; may generate electrostatic charges; can ignite by electric sparks; attacks many metals, resins and plastics; NFPA code: not available

**MEASUREMENT METHODS:** Impinger; reagent; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CA2; R7 R8; S1; S3; A5; CAL.

**MAJOR USES:** Lab reagent; chloromethylation; monitoring indicator for chloromethyl ether; alkylating agent in manufacture of polymers; research chemical; intermediate in the synthesis of anionic exchange strong base resins of the quarternary ammonium type.

**STORAGE:** Keep in a cool, dry place, away from heat and flame.

**FIRE FIGHTING:** Use carbon dioxide, alcohol-proof foam, dry chemical or halogenated extinguishing agents.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.001ppm; OSHA cancer suspect agent; NIOSH occupational carcinogen.

**PERSONAL PROTECTION:** wear gas-tight, fireproof suit; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb in noncombustible material for proper disposal; treat residues and wastes with concentrated aqueous ammonia; keep water away from release; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); contact (redness, burning, prickling); ingestion (abdominal pain, vomiting, sore throat, labored breath).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 210 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide breathing support if necessary; if ingested, drink water.

**KEY REFERENCES:** 3; 4; 5; 14; 16.

### **BROMOFORM (CHBR<sub>3</sub>, 252.75)**

**CAS/DOT #:** 75-25-2/UN2515

**SYNONYMS:** Methyl tribromide, tribromomethane.

**PHYSICAL PROPERTIES:** Colorless to pale yellow liquid; sweetish odor; soluble in benzene, chloroform, alcohol, ether, solvent naphtha and fixed and volatile oils; slightly soluble in water; MP (8.3°C); BP (149°C); OT (1.3 ppm); DN (2.8899 g/ml); ST (41.53 dynes/cm at 20°C); VP (5 mm Hg at 20°C); VD (8.7); HV (9673.3 cal/mol).

**CHEMICAL PROPERTIES:** Attacks some forms of plastics, rubber and coatings; incompatible with metals, strong oxidants, bases lithium and sodium-potassium alloys.

**EXPOSURE ROUTES:** Inhalation (evaporated air near pools, ambient air near factories); ingestion (swimming pools and drinking water disinfected with bromine or bromine compounds); absorption (bromoform in water).

**HUMAN HEALTH RISKS:** EPA cancer risk level:  $9E-4$  mg/m<sup>3</sup>; EPA group B2; probable human carcinogen; Acute Risks: CNS depression; slowing of brain activities; reddening of face; areflexia; convulsions; dizziness; headaches; pulmonary edema; shock; amnesia; irritation causing increases flow of tears and saliva; Chronic Risks: effects of liver, kidney and CNS; lesions in tissues.

**HAZARD RISK:** Non-combustible; toxic gases of hydrogen bromide, bromine and carbon dioxide released during fire; violent reaction with acetone, bases and lithium or sodium-potassium alloy; incompatible with metals, strong oxidants and strong bases; decomposes upon heating producing toxic and corrosive fumes including hydrogen bromide and bromine; NFPA code: not available.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; S3; S40-e; R2; R4; R5; R8; R9; U225 (U waste); Sfl; Sf3; CW4; CW5; T30-e; T799-5055; A1; CAL.

**MAJOR USES:** Used as a solvent for waxes, oils, greases and liquid solvent extractions; used in the chemical synthesis of pharmaceuticals, fire resistant chemicals, gauge fluid, ore flotation and heavy liquid flotation; used in the manufacture of ships, aircraft, medication, antiseptics and rubber.

**STORAGE:** Keep in a tightly closed container; keep in a cool, dry, well ventilated area away from incompatible substances; store only if stabilized.

**FIRE FIGHTING:** Bromoform is non-combustible, use an appropriate agent to extinguish surrounding fire.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (5mg/m<sup>3</sup>); OSHA PEL TWA 0.5 ppm (5mg/m<sup>3</sup>); NIOSH REL TWA 0.5 ppm (5mg/m<sup>3</sup>); IDLH 850 ppm.

**PERSONAL PROTECTION:** wear protective clothing, gloves, and face shields; wear splash proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; use water spray to "knock down" vapor; isolate and remove discharged material.

**HEALTH SYMPTOMS:** inhalation (irritation of nose and throat, provokes flow of tears and saliva); skin absorption (headaches, dizziness, dermatitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1147 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide artificial respiration if necessary.

**KEY REFERENCES:** 3; 4; 5; 14; 16.

**1,3-BUTADIENE (C<sub>4</sub>H<sub>6</sub>, 54.10)****CAS/DOT #:** 106-99-0/UN1010

**SYNONYMS:** Biethylene, bivinyl, gamma-butadiene, vinyl ethylene, pyrrolene erythrene, vinylethylene.

**PHYSICAL PROPERTIES:** Colorless gas; mildly aromatic odor; slightly soluble in water, methanol and ethanol; soluble in organic solvents; MP (-109°C, -164°F); BP (-4.5°C, -24°F); SG (0.621); VD (1.81); VP (2100 mm Hg at 25°C); OT (1.6 ppm).

**CHEMICAL PROPERTIES:** Flammable gas; low ignition energy; forms explosive peroxides in the absence of inhibitors; highly reactive; polymerizes and co-polymerizes easily FP (-76°C); AT (419°C); LFL (2.0%); UFL (11.5%).

**EXPOSURE ROUTES:** Inhalation (motor exhaust, highly industrialized cities and ambient air near oil refineries or chemical factories); ingestion (drinking water and plastic and rubber food containers); occupational exposure.

**HUMAN HEALTH RISKS:** EPA cancer risk level 4E-6 mg/m<sup>3</sup>; EPA group B2: probable human carcinogen; Acute Risks: irritation of eyes, nasal passages, throat and lungs; blurred vision; fatigue; vertigo; nausea; headaches; unconsciousness; burning sensation and frostbite or skin; Chronic Risks: cardiovascular disease; blood disorders; respiratory paralysis.

**HAZARD RISK:** Dangerous fire hazard; incompatible with strong oxidizers, halogens, oxygens and copper alloys; autopolymerizes in the presence of sodium; combustion forms carbon monoxide and carbon dioxide; may form explosive mixture with air; vapors are heavier than air and may travel distances to source of ignition and flash back; closed container may rupture violently when heated; NFPA code: H 2; F 4; R 2.

**MEASUREMENT METHODS:** Two charcoal tubes in series; methylene chloride; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; R7; Sf3; A2; CAL.

**MAJOR USES:** Used in the manufacture of styrene-butadiene rubbers, plastics, acrylics, latex paints and resins; organic intermediate in adiponitrile production.

**STORAGE:** Outside storage is preferred; store in a cool, dry, well ventilated location; keep away from oxidizing materials.

**FIRE FIGHTING:** Use water spray or fog, dry chemical or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2-10 ppm (4.4-22 mg/m<sup>3</sup>); OSHA PEL TWA 1000ppm (2210 mg/m<sup>3</sup>); NIOSH REL TWA reduce to lowest possible level; IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear a rubber suit, rubber boots, and thick rubber gloves; wear chemical-type safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; ventilate area and wash spill site; if in liquid form, absorb as much as possible on paper towels and evaporate in a fume hood; if in gaseous form, shut off leak; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); skin absorption (headaches, drowsiness, and nausea).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5480 mg/kg; Personal protection: use self-contained breathing apparatus; wear rubber boots and heavy rubber gloves; First aid: flush eyes and skin with large amounts of water for at least 15 minutes; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, rinse mouth with water if person is conscious.

**KEY REFERENCES:** 3; 4; 5; 10; 16.

### **CADMIUM COMPOUNDS (CDX, MW OF CD 112.40, FORMULA WEIGHT VARIES BY COMPOUND)**

**CAS/DOT #:** Cd: 7440-43-9/UN2570 (Cadmium dust)

**SYNONYMS:** Colloidal cadmium, cadmium dust, cadmium fume.

**PHYSICAL PROPERTIES:** Soft, silver white metal; usually found in combination with other elements such as oxygen, chlorine or sulfur; malleable or powder; soluble in acids and in ammonium nitrate solution; solubility in water ranges with compound; MP (320.9°C); BP (767°C); DN (8.642 g/ml); VP (1 mm Hg at 394°C).

**CHEMICAL PROPERTIES:** Tarnishes in moist air; corrosion resistance poor in industrial atmospheres; resistant to alkalis.

**EXPOSURE ROUTES:** Inhalation (incineration of municipal waste materials, zinc, lead or copper smelters, cigarette smoke); ingestion (contaminated food or water from the application of phosphate fertilizers).

**HUMAN HEALTH RISKS:** Inhalation human TCLo 1500 ug/m<sup>3</sup>/14y; EPA group B1: probable human carcinogen; Acute Risks: bronchial and pulmonary irritation; impairment of lung function; increased salivation; vomiting; diarrhea; choking; anemia; renal dysfunction; tenesmus; Chronic Risks: kidney effects; proteinuria; decrease in glomerular filtration rate; increased frequency of kidney stone formation; bronchitis; emphysema; skeletal malformations; impaired neurological development; high blood pressure; excess risk of lung cancer.

**HAZARD RISK:** Flammable in powder form; decomposition emits toxic fumes of cadmium; cadmium, salts of cadmium and soluble compounds are highly toxic; incompatible with ignition sources, dust generation, moisture and excess heat; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; acid; atomic absorption spectrometry.

**APPLICABLE REGULATIONS:** Sf3.

**MAJOR USES:** Used in industry for electrodeposited and dipped coatings on metals, bearing and low metal alloys, brazing alloys, nickel-cadmium storage batteries, power transmission wires, TV phosphors, basis of pigments in ceramic glazes, machinery enamels, baking enamels, selenium rectifiers, electrodes for cadmium vapor lamps and photoelectric cells, soft solder and solder for aluminum, deoxidizer in nickel plating; powder used as an amalgam in dentistry; used in fire protection systems; photography and lithography.

**STORAGE:** Keep away from heat, flame and sources of ignition; keep in a tightly closed container in a cool, dry, well ventilated area.

**FIRE FIGHTING:** Use dry chemical and carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (cadmium dust and cadmium oxide) 0.05mg/m<sup>3</sup>; OSHA PEL TWA (cadmium fumes) 0.1mg/m<sup>3</sup>; OSHA PEL TWA (cadmium dust) 0.2mg/m<sup>3</sup>; NIOSH REL TWA (cadmium) reduce to lowest feasible level; IDLH (cadmium dust or fumes) 40mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** dig a pit, pond, lagoon, or holding area to contain material; seal holding areas with an impermeable flexible membrane liner.

**HEALTH SYMPTOMS:** inhalation (throat dryness, coughing, chest pain, headache, irritability); ingestion (vomiting, abdominal pain, increased salivation, anemia).

**GENERAL COMMENTS:** First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 14; 16.

### **CALCIUM CYANAMIDE (CaCN<sub>2</sub>, 80.11)**

**CAS/DOT #:** 156-62-7/UN1403

**SYNONYMS:** Alzodef, calcium carbimide, calcium salt, lime nitrogen, cyanimide, nitro-lime.

**PHYSICAL PROPERTIES:** Glistening, colorless hexagonal crystals when pure, grayish black lumps of powder in commercial form; insoluble in water; MP (1300°C); BP (sublimes at 1500°C); SG (2.29).

**CHEMICAL PROPERTIES:** Non-volatile; non-combustible; decomposes in water, liberating ammonia and acetylene; may polymerize in water or alkaline solutions to dicyanamide.

**EXPOSURE ROUTES:** Occupational exposure through manufacture and use.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin and respiratory tract; gastritis; rhinitis; pharyngitis; laryngitis; tracheobronchitis; flushing of the face, upper body and arms; headaches; dizziness; fatigue; vertigo; nausea; vomiting; tachycardia; hypotension; peripheral neuropathy; Chronic Risks: chronic rhinitis; perforation of the nasal septum; slow healing dermal ulceration.

**HAZARD RISK:** Flammable; reaction with water forms explosive acetylene gas; fire risk with moisture or combined with calcium carbide; decomposition emits toxic fumes of NO<sub>x</sub> and CN<sup>-</sup>; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; gravimetric.

**APPLICABLE REGULATIONS:** CA2; Sf3; CAL.

**MAJOR USES:** Used in the manufacture of refining iron, calcium cyanide, melamine, dicyandiamide and hardening steel; used in fertilizers, defoliants, herbicides, fungicides, pesticides, larvicides, nitrogen products, antiethylic agents and desulfurizing agents.

**STORAGE:** Keep away from flames or sparks.

**FIRE FIGHTING:** Use dry chemical or dry sand; do not use water or foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>; OSHA PEL none; NIOSH REL TWA 0.5 mg/m<sup>3</sup>; IDLH not determined.

**PERSONAL PROTECTION:** Wear impervious protective clothing ,including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust-proof goggles and face shield when working with powders or dust; enclose operations and use local exhaust ventilation at site of chemical release; use a NIOSH approved respirator equipped with particulate (dust/fume/mist) filters where the potential exists for exposures over 0.5 mg/m<sup>3</sup>; where the potential for high exposures exists, use self-contained breathing apparatus.

**SPILL CLEAN-UP:** Dampen solid spill with toluene, then transfer the dampened material to a suitable container; pick up any remaining material with absorbent paper dampened with toluene; absorb liquid spill in dry earth, sand, or vermiculite; remove all sources of ignition; wash all contaminated surfaces with toluene followed by washing with a soap and water solution.

**HEALTH SYMPTOMS:** Inhalation (headache, dizziness, shortness of breath, rapid breathing, oppression in chest, laryngitis, pharyngitis, rhinitis); skin (lesions, ulcers, irritates mucous membranes, flushing of skin); eyes (conjunctivitis); ingestion (shock, vertigo, bronchitis, vasodilation with lowered blood pressure, fatigue, nausea, vomiting, hypotension, dizziness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 158 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of water; if inhaled, remove to fresh air and provide artificial respiration if necessary.

**KEY REFERENCES:** 4; 14; 16.

### **CAPTAN (C<sub>9</sub>H<sub>8</sub>CL<sub>3</sub>NO<sub>2</sub>S, 300.59)**

**CAS/DOT #:** 133-06-2/UN9188

**SYNONYMS:** Captane, amercide, captex, cyclohexene-1,2-dicarboximide, n-trichloromethylmercapto-4-cyclohexene-1,2-dicarboximide.

**PHYSICAL PROPERTIES:** White crystalline substance when pure, yellowish in commercial form; odorless when pure, pungent odor in commercial grade; insoluble in water; slightly soluble in ethylene dichloride and chloroform; soluble in acetone, benzene and toluene; MP(178°C); BP (decomposes); DN (1.5 g/ml); SG (1.74); VP (1E<sup>-5</sup> mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Combustible; attacks metals; reacts with acids and bases; incompatible with strong alkaline materials.

**EXPOSURE ROUTES:** Inhalation (ambient air near factories, application of captan); ingestion (contaminated fruits and vegetables); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B2; probable human carcinogen; Acute Risks: dermatitis; conjunctivitis; vomiting; diarrhea; irritation of eyes, skin, mouth, oral and esophageal mucous membranes; pyrosis; abdominal pains; blurred vision; Chronic Risks: systemic effects on CNS; gonadotropic effects; mutagenic and teratogenic properties.

**HAZARD RISK:** Combustible; fine dust explosive with air; decomposes on heating and burning producing toxic gases including sulfur oxides, nitrogen oxides, hydrogen chloride and phosgene; can produce corrosive vapors; can ignite by electric sparks; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; gravimetric.

**APPLICABLE REGULATIONS:** CA2; F2; Sf1; Sf3; CW1; CW2; CAL.

**MAJOR USES:** Used in agriculture as a fungicide; used in the production of cosmetics, pharmaceuticals, oil-based paints, lacquers, wallpaper paste, plasticizers, polyethylene, vinyl, rubber stabilizers, textiles, bacteriostatic agent in soaps, dermatological anti-infective.

**STORAGE:** Keep separate from strong bases; use floor level ventilation.

**FIRE FIGHTING:** Use water spray, chemical powder, appropriate foam or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV 5 mg/m<sup>3</sup> (skin); OSHA PEL (none); NIOSH REL TWA 5 mg/m<sup>3</sup> (potential occupational carcinogen); IDLH no data (potential occupational carcinogen).

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; enclose operations and use local exhaust ventilation (not if powder) at site of chemical release; use self-contained breathing apparatus; for extra personal protection, use a P2 filter respirator for harmful particles.

**SPILL CLEAN-UP:** Sweep spilled substance into containers; use wet vacuuming or moisten first to prevent dusting; collect remaining material, then review to a safe area; do not wash away into sewer.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes, skin, and upper respiratory system); skin (dermatitis, skin sensitization); eyes (redness, pain, blurred vision); ingestion (diarrhea, vomiting).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 9 g/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary; if ingested, induce vomiting.

**KEY REFERENCES:** 4; 5; 14; 16.

**CARBARYL (C<sub>12</sub>H<sub>11</sub>NO<sub>2</sub>, 201.24)**

**CAS/DOT #: 63-25-2/UN2757**

**SYNONYMS:** Arilat, atoxan, carbatox, caprolin, dicarbam, sevin, n-methyl-carbamate, 1-naphthyl-n-methyl-carbamate, sevin, vioxin.

**PHYSICAL PROPERTIES:** White, crystalline solid; odorless; soluble in water, acetone, isophrone and cyclohexanone; MP (142°C); BP (decomposes before boiling); DN (1.232 at 20°C); VP (0.000041 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Stable to light, acids; noncorrosive; hydrolyzes in alkalies; decomposes at boiling point; FP (203°C); LFL (0.02%); UFL (Not available).

**EXPOSURE ROUTES:** Inhalation (spray drift in regions surrounding agricultural areas, application of the pesticide); ingestion (contaminated food and drinking water); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group D: not classifiable as a human carcinogen; Acute Risks: nausea; vomiting; blurred vision; bronchioconstriction; headache; excessive salivation; diarrhea; eye and skin irritation; respiratory failure; Chronic Risks: memory loss; cholinesterase inhibition; weakness; kidney and liver effects; dermatitis; heart failure.

**HAZARD RISK:** Decomposes upon heating; fine dust explosive with air; may generate electrostatic charges; decomposition emits toxic fumes of NO<sub>x</sub>; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; reagent; visible spectrophotometry.

**APPLICABLE REGULATIONS:** CA2; F2; R4; U279 (Uwaste); Sf1; Sf3; A1; CAL.

**MAJOR USES:** Used as an insecticide, acaricide, molluscicide, animal ectoparasiticide; used to control lepidoptera, coleoptera, earthworms in turf, pests on animals and poultry; used as a growth regulator for fruit thinning; used in medical facilities and sewage treatment plants.

**STORAGE:** Keep stored away from flames or sparks; keep in a tightly closed container.

**FIRE FIGHTING:** Use water spray, carbon dioxide, foam or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5mg/m<sup>3</sup>; OSHA PEL TWA 5mg/m<sup>3</sup>; NIOSH REL TWA 5mg/m<sup>3</sup>; IDLH 100mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear a gas-tight suit and filter mask; use compressed air/oxygen apparatus or any self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area; dissolve in flammable solvent (such as alcohol), and atomize in suitable combustion chamber; carbon or peat may be used as sorbents.

**HEALTH SYMPTOMS:** inhalation (miosis, blurred vision); skin absorption (rhinitis, excessive salivation, sweating); ingestion (abdominal cramps, nausea, vomiting).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 230 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 14; 16.

**CARBON DISULFIDE (CS, 76.13)****CAS/DOT #:** 75-15-0/UN1131**SYNONYMS:** Carbon bisulfide, carbon sulfide, carbon disulphide.**PHYSICAL PROPERTIES:** Colorless liquid when pure, yellow when impure; sweet odor when pure, rotten egg odor when impure; soluble in alcohol, benzene, ether, water; MP (-111.5°C); BP (46.5°C); DN (1.2632 g/ml at 20°C); ST (32 dynes/cm); VP (352.6 mm Hg); OT (0.1-0.2 ppm).**CHEMICAL PROPERTIES:** Incompatible with strong oxidizers, active metals such as sodium, potassium and zinc, rust, halogens and amines; FP (-5°C); AT (99°C); HC (-5814 Btu/lb); LFL (1.3%); UFL (50%); HF (1.049 kcal/mole).**EXPOSURE ROUTES:** Inhalation (air surrounding industrial areas, low amounts from volcanoes and marshes); ingestion (drinking water); occupational exposure.**HUMAN HEALTH RISKS:** Inhalation human TCl<sub>o</sub> 40 mg/m<sup>3</sup>; EPA group D: not classifiable as a human carcinogen; Acute Risks: chest pains, nausea, vomiting, dizziness, fatigue, blurred vision, respiratory failure; Chronic Risks: neurotoxic effects, behavioral changes, coronary heart disease, muscle pain, ocular effects, blisters.**HAZARD RISK:** Flammable liquid; fire hazard when exposed to heat, flame, sparks, friction or oxidizing materials; incompatible with strong oxidizers, active metals such as sodium, potassium and zinc, rust, halogens and amines; vapor ignites on contact with fluorine; potentially explosive when heated in contact with rust, iron; potentially explosive reaction in contact with nitrogen oxide; explodes on contact with permanganic acid; decomposition emits toxic fumes of SO<sub>x</sub>; NFPA code: H 3; F 3; R 0.**MEASUREMENT METHODS:** Charcoal tube; drying tube; toluene; gas chromatography with photometric detection for sulfur, nitrogen or phosphorus.**APPLICABLE REGULATIONS:** CA2; S10; F2; R2; R4; R5; R6; P022 (P waste); Sf1; Sf2; Sf3; Cw1; CW2; T30; T120-d; A1; A2; CAL.**MAJOR USES:** Used in the manufacture of rayon, carbon tetrachloride, floating agents, soil disinfectants, electronic vacuum tubes, optical glass, paint removers, varnishes, rubber cement; used as a solvent in phosphorous, sulfur, selenium, bromine, iodine, fats, resins, rubbers, waxes, lacquers; used as a chemical intermediate in cellophane, rubber compounds, fumigants, rare earth sulfides, xanthates.**STORAGE:** Keep in a tightly closed container, away from heat, sparks or open flame; can be stored in iron, aluminum, glass, porcelain and teflon.**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or foam.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 31mg/m<sup>3</sup>; OSHA PEL TWA 12mg/m<sup>3</sup>; NIOSH REL TWA 1ppm (3mg/m<sup>3</sup>); IDLH 500ppm.**PERSONAL PROTECTION:** wear rubber protective clothing, aprons and gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; prohibit entrance into spaces such as sewers because of danger of explosion; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritation of skin, eyes, and mucous membranes, garlicky breath, palpitations); skin absorption (headaches, vertigo, fatigue).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 3188 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 3; 4; 5; 10; 14; 16.

### **CARBON TETRACHLORIDE (CCL<sub>4</sub>, 153.81)**

**CAS/DOT #:** 56-23-5/UN1846

**SYNONYMS:** Benzinoform, tetrachloromethane, carbon-tet, methane tetrachloride.

**PHYSICAL PROPERTIES:** Colorless, clear, heavy liquid; sweet odor; insoluble in water; miscible with alcohol, ether, chloroform, benzene, solvent naphtha, and most fixed and non volatile oils; MP (-23°C); BP (76.54°C); DN (1.594 at 20°C); ST (270 dynes/cm); OT (<10 ppm); VP (91.3 mm Hg at 20°C)

**CHEMICAL PROPERTIES:** Non-combustable; non-explosive; incompatible with alkali metals, finely powdered metals and oxidizing agents; HC (37.3 kcal/gmol at 20°C)

**EXPOSURE ROUTES:** Inhalation (air from disposal in landfills, air from accidental production and uses, cleaning agents, building materials); ingestion (contaminated drinking water); exposure during manufacture.

**HUMAN HEALTH RISKS:** Inhalation human TCl<sub>o</sub> 45 ppm/3D; EPA cancer risk level 7E-5 mg/m<sup>3</sup>; EPA group B2: probable human carcinogen; Acute Risks: headaches, weakness, lethargy, nausea, delayed pulmonary edema, stomach pains, dermatitis, eye irritation; Chronic Risks: liver and kidney damage; pupillary constriction, coma, tremors, gastrointestinal effects, anorexia, neurological effects.

**HAZARD RISK:** Forms impact-sensitive explosive mixtures with particulates of many metals; violent reactions on contact with fluorine; explosive mixtures with ethylene; incompatible with aluminum trichloride, dibenzol peroxide and potassium-tert-butoxide; decomposition emits toxic fumes of Cl<sup>-</sup> and phosgene; NFPA code: H 3; F 0; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; S1; S50-a; S61; S62; R1; R2; R4; R5; R7; R8; R9; D019 (D waste); U211 (U waste); Sf1; Sf3; CW1; CW2; CW3; CW4; CW5; A1; A2; CAL.

**MAJOR USES:** Used in industry for recovery of tin in tin plating waste, formulation of gasoline additives, refrigerants and propellants, metal degreasing, production of semiconductors, cleaning of machinery and electrical equipment; used as a solvent for rubber cement, oils, fats,

lacquers, varnishes; waxes; used in the synthesis of nylon-7, polymers, organic compounds, soap perfumes.

**STORAGE:** Keep in a tightly closed container, in a cool, dry place.

**FIRE FIGHTING:** Non-combustible, use extinguishing media appropriate for surrounding fire.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5ppm; ACGIH TLV STEL 30ppm(skin); OSHA PEL TWA 10ppm; NIOSH REL TWA 12.6mg/m<sup>3</sup>; IDLH 200ppm.

**PERSONAL PROTECTION:** wear special protective clothing and rubber gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible with materials such as dry earth or sand; isolate material for proper disposal.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin); skin absorption (nausea, dizziness, vomiting and drowsiness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2350 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 16.

### **CARBONYL SULFIDE (COS, 60.08)**

**CAS/DOT #:** 463-58-1/UN not available

**SYNONYMS:** Carbon monoxide monosulfide, carbon oxide sulfide, carbon oxysulfide, oxycarbon sulfide.

**PHYSICAL PROPERTIES:** Colorless gas; typical sulfur odor when pure; liquefies under pressure; hydrolyzed by water; slightly soluble in water alcohols and toluene; MP (-138.2°C, -58.36°F); BP (-50.2°C, -58°F); VP (9412 mm Hg at 25°C); DN (1.24 g/ ml at 87°C)

**CHEMICAL PROPERTIES:** Strong oxidizing agent; reacts with oxidizing agents, acids, water; LFL (11.9%); UFL (29%).

**EXPOSURE ROUTES:** Inhalation (volcanoes); ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: spasms; inflammation and edema of the larynx and bronchi; chemical pneumonitis; pulmonary edema; destructive to mucous membranes, upper respiratory tract, eyes, skin; coughing; wheezing; laryngitis; headaches; nausea; Chronic Risks: serious nervous system impairment with narcotic effects.

**HAZARD RISK:** Highly flammable; highly toxic; corrosive; vapor explosive with air; NFPA Code: H 3; F 4; R 1.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; Sf3; CAL.

**MAJOR USES:** Intermediate for herbicides; intermediate in the synthesis of organic sulfur compounds and alkyl carbonates.

**STORAGE:** Not available.

**FIRE FIGHTING:** Stop flow of gas; use carbon dioxide, dry chemical or water spray.

**EXPOSURE GUIDELINES:** ACGIH TLV none; OSHA PEL none; NIOSH REL none; IDLH none.

**PERSONAL PROTECTION:** Wear protective clothing and rubber gloves; employees should be provided with special clothing designed to prevent freezing of body tissues where exposure to cold equipment, vapors, or liquid may occur; wear gas-proof goggles and face shield; splash-proof chemical goggles and face shield should be worn when working with liquid; enclose operations and use local exhaust ventilation at site of chemical release; use NIOSH approved self-contained breathing apparatus; provide eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Ventilate area of leak to disperse gas; if source of leak is a cylinder, cautiously remove leaking cylinder to a safe location in the open air, and allow cylinder to empty; keep out of confined spaces, such as sewers, due to possibility of an explosion; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (headache, dizziness, confusion, cough, sneezing, irritates nose, throat and lungs); skin/eyes (irritates tissues of mucous membranes, burning sensation); ingestion (nausea, vomiting, weakness, muscle cramps, rapid or irregular heartbeat, unconsciousness, convulsions, coma, sudden collapse, death).

**GENERAL COMMENTS:** First aid: wash eyes immediately with large amounts of water; remove contaminated clothing; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 10; 16.

### **CATECHOL (C<sub>6</sub>H<sub>4</sub>(OH)<sub>2</sub>, 110.12)**

**CAS/DOT #:** 120-80-9/UN2811

**SYNONYMS:** 1,2-benzenediol; 2-hydroxyphenol; o-benzenediol, catechin, o-dihydroxybenzene, pyrocatechol.

**PHYSICAL PROPERTIES:** Colorless tablets or crystals; discolors in air; faint, phenolic odor; soluble in water, chloroform, benzene, alcohol, ether; MP (105°C); BP (240°C); DN (1.341 g/ml at 15°C); VP (0.03 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Combustible; sublimes; volatile with steam; FP (261°F); AT (510°C); LFL (1.4%); UFL (not available).

**EXPOSURE ROUTES:** Ingestion (contaminated drinking water and food); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: eczematous dermatitis; convulsions CNS depression; rise in blood pressure; peripheral vasoconstriction; respiratory failure; Chronic Risks: skin sensitization; effects on liver, kidneys, CNS, cardiovascular system and red blood cells.

**HAZARD RISK:** Combustible when exposed to heat or flame; can react vigorously with oxidizers; hypergolic reaction with concentrated nitric acid; decomposition emits acrid smoke and irritating fumes; NFPA Code: H 3; F 1; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; Sfl; CAL.

**MAJOR USES:** Photographic developer; antiseptic; organic synthesis; developer for fur dyes; used in electroplating, specialty inks, antioxidants, light stabilizers, polymerization inhibitors, lubricating oils.

**STORAGE:** Keep in a tightly closed container; do not allow material to completely dry; keep from contact with oxidizing materials.

**FIRE FIGHTING:** Use water, carbon dioxide or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (23 mg/m<sup>3</sup>) (skin); OSHA PEL TWA (none); NIOSH REL TWA 5 ppm (20 mg/m<sup>3</sup>) (skin); IDLH (not determined).

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear face shield in combination with breathing protection; enclose operations and use local exhaust ventilation at site of chemical release; for extra personal protection, use a P2 filter respirator for harmful particles.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable containers; use wet vacuuming or moisten first to prevent dusting; remove to a safe place.

**HEALTH SYMPTOMS:** Inhalation (cough, labored breathing, burning sensation); skin (redness, skin sensitization, dermatitis); eyes (redness, pain, severe deep burns, tearing); ingestion (abdominal pain, diarrhea, vomiting).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 260 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, drink water or milk.

**KEY REFERENCES:** 4; 5; 10; 14; 16.

**CHLORAMBEN (C<sub>7</sub>H<sub>5</sub>CL<sub>2</sub>NO<sub>2</sub>, 206.02)**

**CAS/DOT #:** 133-90-4/UN not available

**SYNONYMS:** 3-amino-2,5-dichloroacide, benzoic acid, chlorambene.

**PHYSICAL PROPERTIES:** Colorless, crystalline solid; odorless; soluble in ethyl alcohol and water; MP (200°C, 393°F); BP (not available); SG (not available); VP (0.007 mm Hg at 100°C).

**CHEMICAL PROPERTIES:** Not available.

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); absorption (during use as herbicide); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: unlikely to present acute hazard during normal use; mild dermal irritation; Chronic Risks: no information available for humans.

**HAZARD RISK:** Very toxic; decomposes on heating; NFPA code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; F1; Sf3; CAL.

**MAJOR USES:** Used in pesticides, herbicides, plant growth regulation, selective weed control.

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV not established; OSHA PEL not established; NIOSH REL not established; IDLH not established.

**PERSONAL PROTECTION:** Wear gastight suit and compressed air/oxygen apparatus; protective gloves are required; wear chemical safety goggles; handle only in a chemical fume hood; only trained personnel should handle this chemical or its container.

**SPILL CLEAN-UP:** Evacuate area; ventilate area of spill; wear appropriate equipment; sweep up and place in an appropriate container; wash contaminated surfaces to remove any residues.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes and skin); skin (mild dermal irritation); eyes (irritation); ingestion (nausea, vomiting, convulsions, loss of consciousness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 3500 mg/kg. First aid: flush eyes immediately with large amounts of water for several minutes; use plenty of soap and water to cleanse affected areas of skin if no burns have occurred; administer oxygen if breathing is difficult; if cardiac arrest occurs, administer CPR; in case of ingestion, induce vomiting and obtain prompt medical attention.

**KEY REFERENCES:** 14; 16.

**CHLORDANE (C<sub>10</sub>H<sub>6</sub>CL<sub>8</sub>, 409.78)**

**CAS/DOT#:** 57-74-9/UN2762

**SYNONYMS:** Aspon-chlordane, chlortox, chlorindan, chlor kil, chlordan, chlordano, hydro-4,7-methanoinidin.

**PHYSICAL PROPERTIES:** Colorless to amber-colored viscous liquid; pungent, chlorine-like odor; insoluble in water; soluble in kerosene, many organic solvents; decomposes in weak alkalis; MP (-116°C, -176.8°F); BP (175°C, 347°F); VP (0.00001 mm Hg at 25°C); DN (1.6 g/ml at 25°C).

**CHEMICAL PROPERTIES:** Will not polymerize; attacks plastics, rubbers, coatings; strong oxidizer and alkaline reagent; produces HCl upon decomposition; incompatible with strong oxidizers, alkaline reagents and reducing agents; stable chemical; FP (10°F); LFL (1.1%); UFL (6.7%).

**EXPOSURE ROUTES:** Ingestion (contaminated food); digging in soils in areas where it has been applied; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin, nose, throat; dizziness; nausea; abdominal pain; facial congestion; limb convulsions; fever; labored breathing; Chronic Risks: liver and kidney damage; anorexia; weight loss; hepatocellular carcinomas.

**HAZARD RISK:** Dangerous fire hazard; decomposition emits HCl; incompatible with strong oxidizers, alkaline reagents and reducing agents; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; chromosorb tube; toluene; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CA2; S1; S24; S32; S50-a; S61; S62; R4; R5; R7; R8; D020 (D waste); P036 (P waste); Sf1; Sf2; Sf3; CW1; CW2; F4; A1; CAL.

**MAJOR USES:** Used as a pesticide, insecticide and fumigant; used in the chlorination of chlordene; household and veterinary uses.

**STORAGE:** Keep in a cool, dry place; store away from strong bases.

**FIRE FIGHTING:** Use carbon dioxide, foam or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.5mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.5mg/m<sup>3</sup> (skin); IDLH 100mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing and rubber gloves; wear chemical safety goggles; wear face mask with organic vapor canister.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; ventilate area; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (blurred vision, coughing, delirium, confusion, and ataxia).

**GENERAL COMMENTS:** First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 14; 16.

**CHLORINE (CL<sub>2</sub>, 70.90)**

CAS/DOT #: 7782-50-5/UN1017

SYNONYMS: Bertholite, chlore, chlorine mol, molecular chlorine.

**PHYSICAL PROPERTIES:** Dense, greenish-yellow diatomic gas; clear amber liquid; pungent, irritating odor; non-metallic halogen element; soluble in chlorides, alcohols; slightly soluble in cold water; MP (-101°C, -149.8°F); BP (-34.9°C, 30.8°F); VD (2.44); VP (4800 mm Hg at 20°C); SG (2.48).

**CHEMICAL PROPERTIES:** Oxidizing gas under pressure; extremely strong oxidizing agent; non-combustible but supports combustion; dangerous on contact with turpentine, ether, ammonia, hydrocarbons, hydrogen, powdered metals, other reducing materials; combines with moisture to form HCl; FP (0°C).

**EXPOSURE ROUTES:** Inhalation; ingestion (drinking water, swimming water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human LCLo 500 ppm for 5 minutes; Acute Risks: changes in trachea or bronchi; emphysema; pulmonary edema or congestion; irritation of eyes, mucous membranes; liquid burns skin; Chronic Risks: minor changes in pulmonary function.

**HAZARD RISK:** Explodes on contact with molten aluminum, ammonia, amidosulfuric acid, biuret, tert-butanol, 3-chloropropyne, diborine, diethyl ether; ignition or explosion reaction with metals; violently reacts with alcohols; NFPA Code: H 2; F 0; R 1.

**MEASUREMENT METHODS:** Particulate filter; sodium thiosulfate; ion chromatography.

**APPLICABLE REGULATIONS:** CA2; S3; R6; Sfl; Sf2; Sf3; CW2; A1; CAL.

**MAJOR USES:** Used in the manufacture of carbon tetrachloride, trichloroethylene, chlorinated hydrocarbons, polychloroprene, polyvinylchloride, hydrogen chloride, hypochlorous acid, ethylene dichloride, metallic chlorides, chlorobenzene, chloroacetic acid, chlorinated lime, chloroform; Used in the manufacturing process of water purification, flame retardant compounds, paper products, textiles, petroleum products, medicines, antiseptics, insecticides, solvents, paints, plastics, disinfectants, synthetic rubber.

**STORAGE:** Not available.

**FIRE FIGHTING:** Non-flammable, use media appropriate for surrounding fire.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5ppm (49mg/m<sup>3</sup>); STEL 1ppm; OSHA PEL TWA 0.5ppm; STEL 1ppm; NIOSH REL 0.5ppm/15m (1.45mg/m<sup>3</sup>); IDLH 10ppm.

**PERSONAL PROTECTION:** wear impervious clothing; wear chemical safety face shield and rubber gloves; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; apply vapor suppression foam to limit vaporization from liquid release; if in liquid form, absorb as much as possible with materials such as dry earth or sand; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes, skin and nose); skin absorption (respiratory distress, excitement, restlessness, headache, nausea).

**GENERAL COMMENTS:** First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; remove contaminated clothing; if inhaled, remove to fresh air and provide artificial respiration if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 16.

### CHLOROACETIC ACID (CLCH<sub>2</sub>COOH, 94.50)

**CAS/DOT #:** 79-11-8/UN1751

**SYNONYMS:** Alpha chloroacetic acid, chloroethanoic acid, monochloroacetic acid, monochloroethanoic acid.

**PHYSICAL PROPERTIES:** Colorless or white crystals; vinegar odor; soluble in water, acetone, carbon disulfide, benzene, ethanol, diethyl ether, carbon tetrachloride, chloroform; MP (142-145°F, 61-63°C); BP (189°C, 372°F); SG (1.4); VD (3.26); ST (33 dynes/cm at 80°C); VP (1 mm Hg at 43°C).

**CHEMICAL PROPERTIES:** Stable; polymerization will not occur; absorbs water from the air and forms a syrup; corrosive to metals; will react on contact with strong bases and most metals; FP (126°C, 259°F); AT (>500°C > 932°F); LFL (8.0%); UFL (n/a); HC (-1.008 cal/g).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of skin, eyes, upper respiratory tract; destructive to mucous membranes; headache; coughing; wheezing; chest pains; chemical pneumonitis; pulmonary edema; convulsions; nausea; Chronic Risks: blood disorders; liver disorders; kidney damage; CNS damage; heart damage; damage to skeletal muscles; chromosomal mutation data reported.

**HAZARD RISK:** Slight fire hazard; combustible liquid when exposed to heat or flame; corrosive and combustible solid; decomposition emits toxic fumes of hydrogen chloride, phosphine, carbon monoxide, carbon dioxide; incompatible with most metals, strong bases, alkalies, amines, ammonia, strong oxidizers, reducers; NFPA Code: H 3; F 1; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; Sf2; Sf3; CAL.

**MAJOR USES:** Used in the production of pharmaceuticals, indigoid dyes, carboxymethylcellulose, glycine, synthetic caffeine, sarcosine, EDTA; used as a bacteriostat, preservative, herbicide, defoliant.

**STORAGE:** Keep in a cool, dry, well-ventilated, corrosion-proof area; keep container tightly closed and separate from alkalies, alcohols, oxidizers, reducing agents, metals.

**FIRE FIGHTING:** Use water spray, dry chemical, alcohol resistant foam or carbon dioxide.

**SPILL CLEAN-UP:** Sweep spilled substance into containers; wash away remaining material with plenty of water; wastewater can be treated with ammonia, ammonium salts, or amines; after these treatment steps, suspended solids may be separated.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; Short-Term Exposure Limit (STEL) not established; Short-Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established.

**PERSONAL PROTECTION:** wear special protective clothing and self-contained breathing apparatus if intense heat or flame are involved; enclose operations and/or use local exhaust ventilation at site of chemical release; maintain eyewash baths and safety showers in work area.

**HEALTH SYMPTOMS:** Inhalation (cough, sore throat, labored breathing, burning sensation); skin (redness, pain, blisters); eyes (redness, pain, severe deep burns); ingestion (abdominal cramps, burning sensation, collapse).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 76 mg/kg; First aid; flush eyes immediately with water for 15 minutes; wash skin with large amounts of water; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, do not induce vomiting, give large amounts of water, milk or milk of magnesia.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 16.

## 2-CHLOROACETOPHENONE (C<sub>6</sub>H<sub>5</sub>COCH<sub>2</sub>CL<sub>2</sub>, 154.60)

CAS/DOT #: 532-27-4/UN1697

**SYNONYMS:** Chloroacetophenone, Chloromethyl phenyl ketone, CAP, phenacylchloride, mace, tear gas.

**PHYSICAL PROPERTIES:** Colorless to gray crystals; odor resembling apple blossoms; insoluble in water; soluble in alcohol, ether, benzene; OT 0.035 ppm; MP (56.5°C); BP (244°C); VP (5.4E<sup>-03</sup> mm Hg at 20°C); SG (1.32).

**CHEMICAL PROPERTIES:** Stable; incompatible with strong oxidizers, water, alkalis; will not polymerize; HC (-9340 Btu/lb); FP (244°F).

**EXPOSURE ROUTES:** Occupational exposure; exposure to tear gas and chemical mace.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, throat, skin, nose; blurred vision; possible corneal damage; burning in chest; laryngotracheobronchitis; difficulty breathing; loss of reflexes; Chronic Risks: dermatitis; skin sensitization.

**HAZARD RISK:** Combustion will produce carbon dioxide, carbon monoxide, hydrogen chloride; capable of creating dust explosions; incompatible with strong oxidizers, water, alkalis; decomposition emits toxic fumes of Cl; NFPA Code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** Two tenax gas chromatography tubes in series; thermal desorption apparatus; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAL.

**MAJOR USES:** Used in the manufacture of tear gas, mace; pharmaceutical intermediate; alcohol denaturant.

**STORAGE:** Keep away from oxidizers; keep container tightly closed away from water and alkalis.

**FIRE FIGHTING:** Use dry chemical, water spray or mist or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05ppm (49mg/m<sup>3</sup>); OSHA PEL TWA 0.05ppm (0.3mg/m<sup>3</sup>); NIOSH REL TWA 0.05ppm(0.3mg/m<sup>3</sup>); IDLH 15mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and rubber gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** sweep onto paper or other suitable material and cautiously ignite amounts in open areas; dissolve in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber; ventilate area of spill.

**HEALTH SYMPTOMS:** inhalation (tearing and burning of eyes, difficulty in breathing); skin absorption (irritation of skin, intense irritation of eyes); ingestion (agitation, contraction of pupils, loss of reflexes).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 127 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 16.

**CHLOROBENZENE (C<sub>6</sub>H<sub>5</sub>CL, 112.56)**

**CAS/DOT #:** 108-90-7/UN1134

**SYNONYMS:** Benzene chloride, chlorobenzol, monochlorobenzene, phenyl chloride.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; almond-like odor; negligible solubility in water; soluble in alcohol, ether, benzene, chloroform, carbon dioxide, organic solvents; MP (-45°C, -49°F); BP (132°C, 269°F); DN (1.11 g/ml at 20°C); VD (3.9); VP (12 mm Hg at 25°C); ST (33 dynes/cm at 25°C); VS (0.790 cP at 21.1°C).

**CHEMICAL PROPERTIES:** Generally very stable; polymerization will not occur; will react vigorously with strong oxidizers; combustion byproducts include phosgene and HCl gases; FP (28°C); AT (592°C); LFL (1.3%); UFL (7.1%).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of skin, eyes, upper respiratory tract; nausea; vomiting; dizziness; headache; gastrointestinal effects; drowsiness; red urine; irregular pulse; twitching of extremities; Chronic Risks: kidney damage; liver damage; CNS depression; blood disorders; bone marrow disease; lung damage; glandular disorders; may alter genetic material.

**HAZARD RISK:** Dangerous fire hazard when exposed to heat or flame; contact with strong oxidizers may cause fire; vapors may flow to distant ignition sources and flash back; forms explosive mixtures with powdered sodium or phosphorus trichloride and sodium; violent reaction with silver perchlorate and dimethyl sulfoxide; closed containers exposed to heat may explode; decomposition emits toxic gases of hydrogen chloride, phosgene, carbon monoxide, carbon dioxide; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; S1; S10; R2; R4; R5; R8; R9; D021 (D waste); U037 (U waste); Sf1; Sf3; CW1; CW2; CW4; CW5; A1; T30-e; T120-d10; CAL.

**MAJOR USES:** Used in the manufacture of dyes, phenol, aniline, cumene, DDT, chloro-nitrobenzenes, insecticides, adhesives, paints, polishes, waxes, textiles, surface coatings, natural rubber.

**STORAGE:** Outside or detached storage preferred; inside storage should be in a standard, flammable liquids storage room.

**FIRE FIGHTING:** Use alcohol foam, dry chemical or carbon dioxide; water may be ineffective.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm (49mg/m<sup>3</sup>); OSHA PEL TWA 75ppm (350mg/m<sup>3</sup>); NIOSH REL TWA not established; IDLH 1000ppm.

**PERSONAL PROTECTION:** wear impervious clothing, boots, gloves, aprons, etc.; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; flush remaining chlorobenzene with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes, skin and mucous membranes); ingestion (headache, nausea, vomiting, gastrointestinal irritation).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2.29 g/kg; First aid: flush eyes with water for at least 15 minutes; wash skin immediately with large amounts of water for at least 15 minutes; if swallowed, do not induce vomiting, dilute by drinking water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 14; 16.

### CHLOROROBENZILATE (C<sub>16</sub>H<sub>14</sub>CL<sub>2</sub>O<sub>3</sub>, 325.20)

**CAS/DOT #:** 510-15-6/UN not available

**SYNONYMS:** Acar, benzilan, benz-o-chlor, acarben, folbex, 4,4'-dichlorobenzilate, ethyl-4,4'-dichlorophenyl glycollate.

**PHYSICAL PROPERTIES:** Colorless solid; thick, dark yellow liquid; aromatic odor; slightly soluble in water; soluble in most organic solvents; MP (36-37.3°C); BP (146-148°C); DN (1.28 g/ml at 20°C); VP ( $2.2E^{-06}$  mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Very stable; polymerization will not occur; hydrolyzed by alkali and strong acids; incompatible with lime; high affinity for activated charcoal; dehalogenated by sodium in isopropyl alcohol; FP (>200°F); AT (470°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: headache; tiredness; nausea; diarrhea; convulsions; tremors; respiratory failure; irritation of skin, eyes; muscle pains; Chronic Risks: adverse testicular effects; liver damage; kidney damage; affects synthesis of proteins, lipids, detoxification, excretion; CNS damage; blood disorders.

**HAZARD RISK:** Decomposition emits toxic fumes of Cl<sub>2</sub>; incompatible with lime; hydrolyzed in strong alkali or acid; runoff from fire control or dilution water may give off poisonous gases and cause water pollution; NFPA Code: H 2; F 0; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; F4; R4; R5; U038 (U waste); Sf1; Sf3; CAL.

**MAJOR USES:** Used in agriculture as an acaricide for spider mite control, acaricide for citrus crops, cotton, fruits and nuts; used in hives against the bee mite; synergist for DDT.

**STORAGE:** Keep in a dry, well-ventilated, secure area; store away from alkali or strong acids.

**FIRE FIGHTING:** For small fires use dry chemical, carbon dioxide, halon, water spray or foam; for large fires use water spray, fog or foam.

**EXPOSURE GUIDELINES:** ACGIH TLV not established, OSHA PEL not established; NIOSH REL not established; IDLH not determined.

**PERSONAL PROTECTION:** Wear full protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; use a NIOSH-approved pesticide respirator or supplied-air respirator; it should be noted that only trained personnel should handle this chemical or its container.

**SPILL CLEAN-UP:** Evacuate area; ventilate area of leak or spill; sweep up and place in an appropriate container; wash contaminated surface to remove any residues.

**HEALTH SYMPTOMS:** Inhalation (headache, irritates skin and eyes); eyes (vapors may cause burns); skin (fatal if absorbed); ingestion (vomiting, diarrhea, convulsions).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2784-3880 mg/kg; First aid: flush eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, give 1 or 2 glasses of water and induce vomiting; valium may be used to control convulsions.

**KEY REFERENCES:** 14; 16.

**CHLOROFORM (CHCL<sub>3</sub>, 119.38)****CAS/DOT #:** 67-66-3/UN1888**SYNONYMS:** Formyl trichloride, freon-20, methane trichloride, trichloromethane.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; sweet odor; miscible with alcohol, ether, benzene, carbon disulfide, petroleum ether, carbon tetrachloride, fixed and volatile oils; MP (-63°C, -82°F); BP (62°C, 143°F); SG (1.48); ST (27.1 dynes/cm at 20°C); VS (5.63 mP at 20°C); VD (4.13; HV 59.3 cal/g); VP (100 mm Hg at 10.4°C).

**CHEMICAL PROPERTIES:** Generally stable; hazardous polymerization will not occur; develops acidity from prolonged exposure to air and light; addition to acetone in the presence of a base will result in a highly exothermic reaction; reacts vigorously with disilane when exposed to sunlight; FP (not available); AT (>1832°F).

**EXPOSURE ROUTES:** Inhalation (automobile exhaust, atmospheric decomposition of trichloroethylene); ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human T<sub>CLo</sub> 5000 mg/m<sup>3</sup>/5 months; Acute Risks: irritation of skin, eyes and mucous membranes; headaches; fatigue; dizziness; hallucinations; unconsciousness; Chronic Risks: kidney and liver damage; cardiac-respiratory failure; paralysis; hypotension; toxemia; may alter genetic material.

**HAZARD RISK:** Slight fire hazard when exposed to heat; incompatible with acetone, strong alkalis, chemically active metals, dinitrogen tetroxide, fluorine, potassium-tert-butoxide, sodium, sodium hydroxide, methanol, sodium methoxide, triisopropyl phosphine; decomposition emits toxic fumes of hydrogen chloride gas, phosgene gas, carbon monoxide and carbon dioxide; can be explosive when confined with water; poses explosive hazard if present in boiler feed or cooling water; NFPA code: H 2; F 0; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; S3; S40-e; R4; R5; R7; R8; R9; D022 (D waste); U044 (U waste); Sf1; Sf2; Sf3; CW1; CW2; CW3; CW4; CW5; A1.

**MAJOR USES:** Used in pharmaceutical products; used as a solvent for adhesives, pesticides, rubbers, fats, oils, alkaloids, resins; cleansing agent; dry cleaning agent; used in fire extinguishers; chemical intermediate for fluorocarbon, dyes, pesticides, tribromomethane.

**STORAGE:** Keep in a cool, dry, well-ventilated area; keep container tightly closed and isolate from strong alkalis and strong mineral acids.

**FIRE FIGHTING:** Use extinguishing agent suitable for surrounding fire.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm (49mg/m<sup>3</sup>); OSHA PEL TWA 2ppm (9.78mg/m<sup>3</sup>); ceiling level 50ppm (240 mg/m<sup>3</sup>); NIOSH REL ceiling level 2ppm/60min; IDLH 500ppm.

**PERSONAL PROTECTION:** wear full protective clothing (boots, gloves, sleeves, aprons, etc.); wear chemical safety goggles; in high concentrations of vapor, wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible with materials such as dry earth or sand.

**HEALTH SYMPTOMS:** inhalation (irritation of the upper respiratory tract, headache, dizziness, and drowsiness); skin contact (irritation, dermatitis); eye contact (irritation, corneal damage); ingestion (nausea, vomiting, gastrointestinal irritation, burns to mouth and throat).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 908 mg/kg; First aid: flush eyes immediately with large amounts of water for at least 15 minutes; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, drink water or milk and induce vomiting; keep victim warm if unconscious and having convulsions.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 14; 16.

### **CHLOROMETHYL METHYL ETHER (C<sub>2</sub>H<sub>5</sub>CLO, 80.51)**

**CAS/DOT #:** 107-30-2/UN1239

**SYNONYMS:** Chlorodimethyl ether, chloromethoxymethane, dimethylchloroether, methylchloromethyl ether, monochlorodimethyl ether.

**PHYSICAL PROPERTIES:** Colorless to faint yellow, oily liquid; irritating odor; decomposes easily in water; volatile liquid; MP (-103.5°C); BP (59.15°C); VP (3.55 psi at 20°C); SG (1.06).

**CHEMICAL PROPERTIES:** FP (15°C).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: dermatitis; burns; coughing; laryngitis; headaches; nausea; destructive to mucous membranes, upper respiratory tract, eyes and skin; chemical pneumonitis; pulmonary edema; Chronic Risks: chronic bronchitis; tumors; cancer.

**HAZARD RISK:** Highly flammable; combustion forms toxic vapors of phosgene, carbon monoxide and hydrogen chloride; vapor/air mixtures are explosive; caustic to metals present in water; decomposes in water to produce hydrogen chloride and formaldehyde; reacts with rubber; readily hydrolyzed; NFPA code: not available.

**MEASUREMENT METHODS:** Impinger; hexane; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CAA; Sfl; Sf3; A1.

**MAJOR USES:** Chloroalkylating agent in the preparation of anionic exchange resins; lachrimatory agent; intermediate for chloromethylated compound; used in the process of hydrochlorination of methanol and formaldehyde; used in the production of chloromethylated compounds.

**STORAGE:** Keep in a cool, dry place.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or foam.

**EXPOSURE GUIDELINES:** ACGIH TLV, Suspected Human Carcinogen; OSHA, Cancer Suspect Agent; NIOSH REL TWA use 29 CFR 1910.1006.

**PERSONAL PROTECTION:** use only in a chemical fume hood; use self-contained breathing apparatus; wear safety goggles, chemical resistant gloves and protective clothing.

**SPILL CLEAN-UP:** absorb as much as possible with noncombustible material such as dry earth or sand for proper disposal; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); skin absorption (coughing, respiratory system, headache, nausea).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 817 mg/kg;

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

### **CHLOROPRENE (C<sub>4</sub>H<sub>5</sub>CL, 88.54)**

**CAS/DOT #:** 126-99-8/UN1991

**SYNONYMS:** Neoprene, beta-chloroprene, chlorobutadiene, 2-chloro-1,3-butadiene.

**PHYSICAL PROPERTIES:** Colorless liquid; slightly soluble in water; soluble in ether, acetone, benzene, alcohol and diethyl ether; pungent, ether like odor; MP (-130°C, -202.6°F); BP (59.4°C, 139°F); DN (0.958 g/ml); VD (3.0); 0T (15 ppm); VP (174 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Polymerizes on standing; will react with peroxides and oxidizers, liquid or gaseous fluorine; LFL (4.0%); UFL (20%); AT (39°F); FP (-4° F).

**EXPOSURE ROUTES:** Inhalation and adsorption from occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of respiratory tract; asphyxia; dermatitis; conjunctivitis; corneal necrosis; anemia; temporary hair loss; Chronic Risks: severe degenerative changes in vital organs; reproductive effects.

**HAZARD RISK:** Dangerous fire hazard when exposed to heat or flame; autooxidizes in air to form an unstable peroxide; decomposition emits toxic fumes of Cl<sup>-</sup>; reacts with oxidizing materials; incompatible with chromic anhydride; NFPA Code: H 2 F 3 R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; D waste; R4; R5; Sf3; T120-a; CAL.

**MAJOR USES:** Used in the manufacture of artificial rubber, adhesives for food packaging, wire and cable jackets, gaskets, roof coatings, binders for fibers.

**STORAGE:** Not available.

**FIRE FIGHTING:** Shut off fuel source; use water spray, carbon dioxide, dry chemical or alcohol foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (skin); OSHA PEL TWA 25 ppm (skin); NIOSH TEL CL 1 ppm (3.6mg/m<sup>3</sup>); IDLH 300ppm.

**PERSONAL PROTECTION:** wear protective clothing and chemical safety goggles; wear an air-supplied respirator of self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb on paper towels and evaporate in a fume hood; cautiously ignite paper in open areas away from combustible materials; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (fatigue, psychic changes, oppression in chest, sub-sternal pain, tachycardia); skin absorption (dermatitis, temporary loss of hair).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 450 mg/kg; First aid: flush eyes with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support; if swallowed, gastric lavage followed by saline catharsis.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

### **CHROMIUM COMPOUNDS (CRX, MW OF CR 52.0, FORMULA WEIGHT VARIES BY COMPOUNDS)**

**CAS/DOT #:** Cr: 7440-47-3/Cr VI: UN 1463

**SYNONYMS:** Chrome, chromium metal, synonyms vary by compound.

**PHYSICAL PROPERTIES:** Steel-gray metallic pieces, powders and flakes; strong and varied colors; soluble in acids (except nitric) and strong alkalies; chromium III compounds are sparingly soluble in water; chromium IV compounds are readily soluble in water; MP (1890°C); BP (2672°C); VP (1 mm Hg at 1616°C); VD (7.1 g/cm<sup>3</sup>); HV (81.7 kcal/g-atom); HF (3.5 kcal/g-atom).

**CHEMICAL PROPERTIES:** Attacked by caustic alkalis and alkali carbonates; not oxidized by air; active form reacts readily with dilute acids to form chromous salts; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; occupational exposure.

**HUMAN HEALTH RISKS:** Chromium VI is much more toxic than chromium III; EPA group A: human carcinogen (chromium VI); EPA group D: not classifiable as to carcinogenicity (chromium III); Acute Risks: coughing; wheezing; gastrointestinal effects; neurological effects; skin burns; irritation of nose, lungs, stomach and intestine; perforation of nasal septum; Chronic Effects: bronchitis; decreased pulmonary function; asthma; nasal itching and soreness; effects on liver and kidneys; gastrointestinal and immune system effects; blood effects; ulceration of the skin; increased risk of lung cancer.

**HAZARD RISK:** Powder form is combustible; moderate fire and explosion hazard when exposed to heat or ignition sources; incompatible with strong oxidizers, mineral acids, ammonium nitrate, hydrogen peroxide, chlorates and sulfur dioxide; reacts readily with dilute acids to form chromous salts; NFPA code:Cr VI: H 3; F 0; R1.

**MEASUREMENT METHODS:** Particulate filter; acid; atomic adsorption spectrometry; inductively coupled plasma.

**APPLICABLE REGULATIONS:** Sf3.

**MAJOR USES:** Used for making steel, alloys and bricks in furnaces; increases resistance and durability in metals; protective coating for automotive equipment and accessories; chrome plating; manufacture of dyes and pigments; textiles; toner for copying machines; treatment of cooling tower water.

**STORAGE:** Keep in a cool, dry, well-ventilated area, away from heat or ignition sources and oxidizing agents.

**FIRE FIGHTING:** Use water spray or fog, dry chemical, carbon dioxide or sand.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (Cr metal and Cr (II) and Cr(III) compounds) 0.5mg/m<sup>3</sup>; ACGIH TLV TWA (water soluble Cr(VI) compounds) 0.05 mg/m<sup>3</sup>; OSHA PEL TWA (Cr metal and insoluble compounds) 1mg/m<sup>3</sup>; OSHA PEL TWA (Cr(II) and Cr(III) compounds) 0.5mg/m<sup>3</sup>; NIOSH REL CL (chromic acid) 0.2mg/m<sup>3</sup>; NIOSH REL TWA (chromic acid) 0.05mg/m<sup>3</sup>; NIOSH REL TWA (other Cr(VI) compounds) 0.025 mg/m<sup>3</sup>; NIOSH REL TWA (carcinogenic Cr (VI) compounds) 0.001mg/m<sup>3</sup>; IDLH (Cr(II) compounds) 250mg/m<sup>3</sup>; IDLH (Cr (III) compounds) 25mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full rubberized safety clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible in dry earth or sand; deposit in sealed containers or place in a secured sanitary landfill; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (eye and skin irritation); contact (corrosive on skin, dermatitis, burning).

**GENERAL COMMENTS:** First aid: flush eyes immediately with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, give water to drink and induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

**COBALT COMPOUNDS (COX, MW OF CO 58.93, FORMULA WEIGHT VARIES BY COMPOUNDS)**

**CAS/DOT #:** Co: 7440-48-4/UN not available

**SYNONYMS:** Cobalt oxide, cobalt chloride, aquacat, cobalt metal, fume and dust, cobalt carbonyl, cobalt hydrocarbonyl, synonyms vary by compound.

**PHYSICAL PROPERTIES:** Steel-gray, shiny, hard metal; ductile; somewhat malleable; ferromagnetic; insoluble in water; readily soluble in nitric acid; MP (1493°C); BP (3100°C); HF (62 cal/g); SG (8.92).

**CHEMICAL PROPERTIES:** Stable in air or water at ordinary temperature; slowly attacked by HCl or cold sulfuric acid; corrodes readily in air; incompatible with strong oxidizing agents; hazardous polymerization will not occur; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Naturally found in the environment; Inhalation (burning coal and oil, dust); ingestion (drinking water, sea water); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation to eyes, skin and respiratory tract; coughing; shortness of breath; asthma; congestion; edema; hemorrhage of the lung; nausea; vomiting; depression of erythrocyte production; abdominal pain; Chronic Risks: lung disease; pneumonia; fibrosis; cardiac effects; liver and kidney effects; enlargement of the heart; cardiomyopathy; left ventricle failure; gastrointestinal effects; blood effects; dermatitis.

**HAZARD RISK:** Powdered cobalt ignites spontaneously in air; ignites on contact with bromine pentafluoride; incandescent reaction with acetylene or nitryl fluoride; explosive reaction with hydrazinium nitrate, ammonium nitrate plus heat, 1,3,4,7-tetramethylisoindole; may produce acrid smoke and fumes when heated to decomposition; NFPA code: H2; F0; R0 (cobalt oxide and cobalt chloride).

**MEASUREMENT METHODS:** Particulate filter; acid; atomic adsorption spectrometry.

**APPLICABLE REGULATIONS:** SE3.

**MAJOR USES:** Used in the manufacture of pigments, superalloys; cobalt salts; experimental medicine; electroplating ceramics; lamp filaments; glass; paints; varnishes; cements; jet engines.

**STORAGE:** Keep in a tightly closed container, in a cool, dry place; containers of these compounds may be hazardous when empty since they retain product residues (solids, dust).

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (cobalt metal, dust and fume) 0.02 mg/m<sup>3</sup>; OSHA PEL TWA (cobalt metal, dust and fume) 0.1mg/m<sup>3</sup>; NIOSH REL TWA (cobalt metal, dust and fume) 0.05mg/m<sup>3</sup>; IDLH (cobalt metal, dust and fume) 20mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear protective clothing, rubber gloves and boots; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** flush liquid spills with large amounts of water and channel to a treatment system or holding tank; remove dry material by vacuuming or wet mopping.

**HEALTH SYMPTOMS:** inhalation of dust (pulmonary symptoms; powder may cause dermatitis); ingestion of soluble salts (nausea and vomiting by local irritation).

**GENERAL COMMENTS:** Do not eat, drink or smoke in the workplace; avoid inhaling dust; First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

**COKE OVEN EMISSIONS (EMISSIONS ARE MADE UP OF 53% HYDROGEN, 26% METHANE, 11% NITROGEN, 7% CARBON MONOXIDE AND 3% HEAVIER HYDROCARBONS, FORMULA WEIGHT NOT APPLICABLE)**

**CAS/DOT #:** not available

**SYNONYMS:** Coke oven gas, synonyms vary by constituent.

**PHYSICAL PROPERTIES:** Mixture of coal tar, tar pitch and creosote; brownish thick liquid or semisolid; naphthalene like odor.

**CHEMICAL PROPERTIES:** not available.

**EXPOSURE ROUTES:** Inhalation; dermal contact (used to treat skin disorders); occupational exposure in the aluminum, steel graphite, electrical and construction industries, coking and coal tar production plants.

**HUMAN HEALTH RISKS:** EPA cancer risk level  $2E-6$  mg/m<sup>3</sup>; Acute Risks: irritation of eyes and respiratory system, coughing, wheezing and breathing difficulty; Chronic Risks: possible carcinogen.

**HAZARD RISK:** NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; benzene; gravimetric.

**APPLICABLE REGULATIONS:** CA2; D waste; A1; A4; CAL.

**MAJOR USES:** Used as raw materials for plastics, solvents, dyes, drugs, paints, pipe coatings, roads, roofing, pesticides, sealants, to produce hydrogen, to extract metal from their ores, to manufacture graphite and electrodes, coal tar used in treatment of skin disorders.

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV (coal tar pitch volatiles, benzene soluble ) 0.2 mg/m<sup>3</sup>; OSHA PEL (coal tar pitch volatiles, benzene soluble) 0.2 mg/m<sup>3</sup>; OSHA TLV (coke oven emissions) 0.150 mg/m<sup>3</sup>; NIOSH REL (coal tar pitch volatiles, benzo(a)pyrene) 0.1 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** use asbestos protective clothing and face protection; flame-resistant gloves are also recommended, as well as flame retardant jackets and pants; use insulated footwear and safety shoes; wear protective helmets and vented safety goggles; workers should be supplied with appropriate respiratory equipment.

**SPILL CLEAN-UP:** use engineering controls and work practices as soon as possible; clean coke oven doors before each charge to make sure there is a metal-to-metal fit during coking to prevent emissions from leaking out; cut off gas supply by purging pipes with steam or an inert gas.

**HEALTH SYMPTOMS:** inhalation (stupor, vertigo, bronchitis, pneumoconiosis, emphysema, headache, conjunctivitis); contact (coughing, wheezing, breathing difficulties, sunburn to photosensitization of skin, skin lesions, pigmentation of the skin).

**GENERAL COMMENTS:** Original NESHAP; First aid: wash eyes immediately with large amounts of water; if inhaled, remove to fresh air and provide artificial respiration if necessary.

**KEY REFERENCES:** 4; 5; 7; 13; 16.

**CRESOLS (C<sub>7</sub>H<sub>8</sub>O, 108.14)****CAS/DOT #:** 1319-77-3/UN2076**SYNONYMS:** Cresylic acid, cresylsyre, crysylol, methylphenol, pure cresol, tricresol.**PHYSICAL PROPERTIES:** Colorless, yellowish or pink liquid; phenolic odor; soluble in ethyl alcohol; MP (11-35°C); BP (201°C); VD (3.7); DN (0.7275 g/ml at 20°C); OT (0.00028 ppm); HF (3095 cal/gmol); HV 10801 cal/gmol).**CHEMICAL PROPERTIES:** FP (43°C open cup, 86°C closed cup); LFL (1.1%); UFL (1.4%); AT (598°C).**EXPOSURE ROUTES:** Inhalation (car exhaust, electrical power plant emissions, cigarette smoke, municipal solid waste incinerators); ingestion (contaminated food); absorption; occupational exposure.**HUMAN HEALTH RISKS:** Acute Risks: headaches; vomiting; drowsiness; irritation of upper respiratory tract; gastrointestinal irritation; lesions of the mouth and esophagus; pulmonary edema; burns to mouth and throat; pancreatic complications; Chronic Risks: Damage to liver, lungs, CNS, kidneys, blood.**HAZARD RISK:** Flammable; incompatible with strong oxidizers; decomposition emits carbon monoxide and carbon dioxide; NFPA code: H 3; F 2; R 0.**MEASUREMENT METHODS:** Silicon dioxide; acetone; gas chromatography.**APPLICABLE REGULATIONS:** C&Sf; CW1; CW5; D waste; A1.**MAJOR USES:** Laboratory reagent; solvent for wire enamels; ore flotation agent; disinfectant; preservative; intermediate for cresol phosphates, phenolic resins, tricresylphosphate, cleaning compounds; used in lube oil refining and additives; carbon removal from engines.**STORAGE:** Keep away from heat, flame, other sources of ignition and light.**FIRE FIGHTING:** Use water spray, alcohol foam, carbon dioxide or dry chemical powder.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5ppm (skin); OSHA PEL TWA 5ppm (22mg/m<sup>3</sup>)(skin); NIOSH REL TWA 2.3ppm (10mg/m<sup>3</sup>); IDLH 250ppm.**PERSONAL PROTECTION:** wear special protective clothing, i.e., rubber coveralls/apron, rubber shoes or boots; wear chemical safety glasses; wear self-contained breathing apparatus.**SPILL CLEAN-UP:** approach from upwind; contain spill and dispose properly; if dissolved, absorb as much as possible with materials such as dry earth or activated carbon; remove all ignition sources.**HEALTH SYMPTOMS:** inhalation (irritation of nose, throat, and eyes); skin contact (intense burning, loss of feeling, white discoloration, softening, gangrene); ingestion (burning sensation in mouth and esophagus, vomiting).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1454 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 16.

### **M-CRESOL (C<sub>7</sub>H<sub>8</sub>O, 108.14)**

**CAS/DOT #:** 108-39-4/UN2076

**SYNONYMS:** 3-cresol, m-cresylic acid, m-methylphenol, m-oxytoluene, m-toluol, 1-hydroxy-3-methylbenzene.

**PHYSICAL PROPERTIES:** Colorless to yellow liquid; phenolic odor; miscible with alcohol chloroform and ether; soluble in solution of fixed alkali hydroxides; MP (10.9°C, 51.6°F); BP (202.8°C, 397.0°F); SG (1.034); VP (0.138 mm Hg at 25°C); VD (3.72).

**CHEMICAL PROPERTIES:** Incompatible with strong acids and bases; FP (86°C, 186.8°F); AT (557°C, 1034.6°F); LFL (1.06%); UFL (1.35%).

**EXPOSURE ROUTES:** Inhalation (car exhaust, electrical power plants; municipal solid waste incinerators; oil refineries; cigarettes; homes heated with coal, oil or wood); ingestion (various foods); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group C: possible human carcinogen; Acute Risks: destructive to mucous membranes and upper respiratory tract; irritation to skin and eyes; Chronic Risks: tumors: effects on blood, liver, kidneys and CNS.

**HAZARD RISK:** Flammable when exposed to heat or flame; moderately explosive in vapor form when exposed to heat or flame; decomposition emits carbon monoxide and carbon dioxide; NFPA code: H 3; F 1; R 0.

**MEASUREMENT METHODS:** Silicon gel; acetone; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; D024 (D waste); R5; Sf1; Sf3; T120-a; T799-18; CAL.

**MAJOR USES:** Used in the production of herbicides, pyrethroid insecticides, antioxidants, disinfectants, fumigants, photographic developers, explosives.

**STORAGE:** Keep in a tightly closed container away from heat and open flame; store in a cool, dry place.

**FIRE FIGHTING:** Use dry chemical, water spray, chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; OSHA PEL TWA 5 ppm (22 mg/m<sup>3</sup>) (skin); NIOSH REL TWA 2.3 ppm (10 mg/m<sup>3</sup>); IDLH 250 ppm.

**PERSONAL PROTECTION:** Wear full protective clothing, including neoprene rubber boots, gloves, and suits; wear splash-proof safety goggles; above 86°C, use a closed system of

local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN UP:** Collect leaking liquid in sealable containers or absorb in sand or other inert absorbent; flush remaining liquid with large amounts of water, but not into confined spaces such as sewers due to possibility of explosion.

**HEALTH SYMPTOMS:** Inhalation (cough, headache, labored breathing, nausea, unconsciousness); skin (roughness, dermatitis), eyes (severe deep burns); ingestion (dizziness, dullness, headache, unconsciousness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 242 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 4; 5; 6; 10; 14; 16.

### **O-CRESOL (C<sub>7</sub>H<sub>8</sub>O, 108.14)**

**CAS/DOT #:** 95-48-7/UN2076

**SYNONYMS:** 2-cresol, o-cresylic acid, 1-hydroxy-2-methylbenzene, o-hydroxytoluene, o-methylphenol, o-toluol.

**PHYSICAL PROPERTIES:** Colorless, white crystals; soluble in alcohol, chloroform, ether, hot water, fixed alkali hydroxides, benzene and carbon; phenolic odor; MP (30.9°C, 87.6°F); BP (191°C, 375.8°F); SG (1.05); VP (1 mm Hg at 38.2-53°C); VD (3.72); VS (4.49 cP at 40°C); HV (52.25 kJ/mole); OT (0.26 ppm).

**CHEMICAL PROPERTIES:** Darkens when exposed to air or light with age; highly corrosive; reacts with oxidizing materials, acids and bases; FP (81.1°C); LFL (1.4%); UFL(n/a); AT (599°C). (81.1 °C, 180°F).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA RfD 0.05 mg/kg/d; Acute Risks: corrosive allergen; corrosive to body tissues; skin and eye irritation; Chronic Risks: kidney and liver damage; dermatitis; suspected carcinogen.

**HAZARD RISK:** Flammable when exposed to heat, flame or oxidants; NFPA code: H 3; F 2; R 0.

**MEASUREMENT METHODS:** Silicon gel; acetone; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; R1; D waste; Sf1; Sf2; Sf3; T120-a.

**MAJOR USES:** Used in the manufacture of phosphate, coumarin, salicylaldehyde, disinfectants, solvents, resins, scouring agents, herbicides; extraction of ore.

**STORAGE:** Keep in a tightly closed container; store in a cool, dry, well-ventilated area.

**FIRE FIGHTING:** Use water spray, dry chemical, foam or carbon dioxide.

**SPILL CLEAN-UP:** Sweep spilled substance into containers; use wet vacuuming or moisten first to prevent dusting; cautiously collect remaining material, then remove to a safe place.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (22 mg/m<sup>3</sup>) (skin); OSAH PEL TWA 5 ppm (22 mg/m<sup>3</sup>) (skin); NIOSH REL TWA 2.3 ppm (10 mg/m<sup>3</sup>); IDLH 250 ppm.

**PERSONAL PROTECTION:** Wear full protective clothing, including rubber shoes or boots, rubber gloves, coveralls or rubber apron; wear chemical safety goggles; above 81°C, use a closed system of local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus.

**SPILL CLEAN UP:** Collect leaking liquid in sealable containers or absorb in sand or other inert absorbent; flush remaining liquid with large amounts of water, but not into confined spaces such as sewers due to possibility of explosion.

**HEALTH SYMPTOMS:** See o-Cresol.

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 121 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 4; 5; 6; 10; 11; 14; 16.

### **P-CRESOL (C<sub>7</sub>H<sub>8</sub>O, 108.14)**

**CAS/DOT #:** 106-44-5/UN2076

**SYNONYMS:** 4-cresol, p-cresylic acid, p-oxytoluene, paramethyl phenol, p-tolyl alcohol, hydroxy toluene, 4-methylphenol.

**PHYSICAL PROPERTIES:** White or colorless crystals; phenolic odor; soluble in water, organic solvents, alcohol, ether, acetone and benzene; MP (34.8°C, 94.6 °F); BP (201.9°C; 395.4°F); OT (0.2 ppm); DN (1.0178 g/ml at 20°C); ST (41.8 dynes/cm); VS (7.0 cP at 40°C); VP (0.11 mm Hg at 25°C); VD (3.72).

**CHEMICAL PROPERTIES:** Volatile in steam; FP (86°C); AT (558°C); HC (882.5 kJ/g at 20°C); LFL (1.0%); UFL (n/a). (86°C, 186.8°F); (558°C, 1036.4°F).

**EXPOSURE ROUTES:** Inhalation (car exhaust, electrical power plants; municipal solid waste incinerators; oil refineries; cigarettes; homes heated with coal, oil or wood); ingestion (various foods); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group C: possible human carcinogen; Acute Risks: eye, skin, respiratory tract burns; nasal constriction; gastrointestinal effects; throat and skin irritation; Chronic Risks: effects on blood, liver, kidneys, CNS; abdominal pain; tumors; chemical pneumonitis; digestive tract burns.

**HAZARD RISK:** Combustible when exposed to heat or flame; moderately explosive in vapor form when exposed to heat or flame; incompatible with bases, chlorosulfonic acid, nitric acid, oleum and strong oxidizers; decomposition emits carbon monoxide and carbon dioxide; NFPA code: H 3; F 2; R 0.

**MEASUREMENT METHODS:** Silicon gel; acetone; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; R5; D025 (D waste); Sf1; Sf3; T120-a; T799-18; CAL.

**MAJOR USES:** Used in the production of disinfectants, explosives, synthetic perfumery materials, metal cleaning agents, phenolic resins, petroleum, paint; solvent for wire enamels; chemical intermediate for tricresyl phosphate, cresyl diphenyl phosphate.

**STORAGE:** Keep in a tightly closed container; store in a cool, dry, well-ventilated area.

**FIRE FIGHTING:** Use dry chemical, water spray, carbon dioxide or alcohol foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (22 mg/m<sup>3</sup>) (skin); OSAH PEL TWA 5 ppm (22 mg/m<sup>3</sup>) (skin); NIOSH REL TWA 2.3 ppm (10 mg/m<sup>3</sup>); IDLH 250 ppm.

**PERSONAL PROTECTION:** Wear rubberized protective clothing, including chemical-resistant gloves; wear face shield or eye protection in combination with breathing protection; above 86°C, use a closed system of local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus.

**SPILL CLEAN UP:** Sweep spilled substance into containers; use wet vacuuming or moisten first to prevent dusting; cautiously collect remaining material, then remove to a safe place.

**HEALTH SYMPTOMS:** inhalation (headache, cough, burning sensation, labored breathing, nausea, vomiting, irritates nose or throat); skin (redness, intense burning, loss of feeling, white discoloration blisters); eyes (swelling of conjunctiva, severe deep burns); ingestion (abdominal cramps, burning sensation in mouth and esophagus, vomiting, collapse).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 207 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 4; 5; 6; 10; 11; 14; 16.

### **CUMENE (C<sub>9</sub>H<sub>12</sub>, 120.21)**

**CAS/DOT #:** 98-82-8/UN1918

**SYNONYMS:** Cumol, isopropyl benzene, 2-phenylpropane.

**PHYSICAL PROPERTIES:** Colorless liquid; gasoline-like odor; volatile; MP (-96°C); BP (152.4°C); SG (0.862); ST (28.2 dynes/cm at 20°C); HV (10335 gcal/gmol); VP (10 mm Hg at 38.3°C); VD (4.1); OT (0.012 ppm).

**CHEMICAL PROPERTIES:** Incompatible with oxidizing agents; FP (46°C); AT (795°F); LFL (1.1%); UFL (8.0%).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation to eyes, mucous membranes, skin and upper respiratory tract; dermatitis; narcotic effects; Chronic Risks: damage to lungs, liver, kidneys and CNS.

**HAZARD RISK:** Incompatible with oxidizing agents; combustion by products are carbon monoxide and carbon dioxide; NFPA code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography.

**APPLICABLE REGULATIONS:** CAA; F2; S40; R4; P waste; T120-d; Sfl; Sf3; A1.

**MAJOR USES:** Thinner for paints, lacquers and enamels; solvent; catalyst for acrylic and polyester type resins; gasoline blending; raw material for peroxides and oxidation catalysts; used in the manufacture of styrene, phenol, acetophenone, polymerization catalysts, al-  
phamethylstyrene, diisopropylbenzene.

**STORAGE:** Keep in a cool, dry place; Fire Fighting: use carbon dioxide, dry chemical powder or foam.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50ppm (skin); OSHA PEL TWA 50ppm (245mg/m<sup>3</sup>)(skin); NIOSH REL TWA 50ppm (245mg/m<sup>3</sup>)(skin); IDLH 900ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb in noncombustible material and dispose or properly; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); skin absorption (headache, narcotic effects).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1400 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 16.

## **CYANIDE COMPOUNDS (CNX, MW OF CN 26.02, FORMULA WEIGHT VARIES BY COMPOUNDS)**

**CAS/DOT #:** CN: 57-12-5/UN1588

**SYNONYMS:** Cyanide anion, hydrocyanide, potassium cyanide, sodium cyanide, formonitrile, potassium salt.

**PHYSICAL PROPERTIES (Hydrogen Cyanide):** Colorless gas; bitter, almond odor; miscible in water and ethanol; MP (-13.24°C); BP (25.7°C); OT (0.58 ppm); DN (0.6884 g/ml at 20°C); VP (264.3 mm Hg at 0°C).

**CHEMICAL PROPERTIES (Hydrogen Cyanide):** AT (538°C); FP (-17.8°C closed cup); LFL (5.6%); UFL (40%).

**EXPOSURE ROUTES:** Inhalation (automobile exhaust, smoking, emissions from municipal waste incinerators, chemical industries and metal manufacturing industries); ingestion (wastewater facilities, groundwater near landfills); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: salivation; shortness of breath; convulsions; vertigo; nausea; Chronic Risks: effects on brain, lungs, heart, CNS; tremors; loss of appetite; deafness; loss of muscle coordination; respiratory and cardiovascular effects.

**HAZARD RISK:** Flammable by chemical reaction with heat. Moisture and acid; reaction with hypochlorite solutions may be violent at pH 10-10.3; explodes if melted with nitrates or chlorates; contact with acid, acid fumes, water or steam emits toxic and flammable vapors of CN<sup>-</sup>; NFPA code: sodium cyanide: H 3; F 0; R 0.

**MEASUREMENT METHODS:** Filter plus bubbler; hydroxide; ion-specific electrode.

**APPLICABLE REGULATIONS:** Sf3.

**MAJOR USES:** Production of organic chemicals; insecticide for fumigating enclosed spaces; gas chamber executions; electroplating; metal treatment.

**STORAGE:** Keep away from heat, flame and sources of ignition; keep in a tightly closed container; store in a cool, dry, well-ventilated area.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm; OSHA PEL TWA 5 mg(CN)/m<sup>3</sup>; NIOSH REL CL 5 mg(CN)/m<sup>3</sup>/10m (4.7 ppm/10M); IDLH 25 mg(CN)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, and gas-tight suit; wear dust- and splash-proof safety goggles; a closed system of local exhaust ventilation is required to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear positive-pressure self-contained breathing apparatus in unknown concentrations of IDLH conditions; maintain eyewash baths or safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; spills should be promptly and carefully cleaned up by shoveling the material into a suitable dry container; any dispersal of dust into the air should be minimized; keep water away from release.

**HEALTH SYMPTOMS:** inhalation (difficulty breathing, irregular heartbeat, uncontrolled movement, convulsions, pain in the heart area, vomiting, blood changes, headache, enlarge thyroid glands, possible death); skin contact (irritates skin, may cause sores); ingestion (salivation, rapid breathing, low blood pressure, nausea, vomiting, shortness of breath, high cyanide levels in blood, nerve damage, anxiety, giddiness, paralysis, cardiac arrhythmias, transient respiratory stimulation, lower jaw stiffness).

**GENERAL COMMENTS:** First aid: wash eyes and skin immediately with large amounts of water; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

## **2,4-D, SALTS AND ESTERS (C<sub>8</sub>H<sub>6</sub>CL<sub>2</sub>O<sub>3</sub>, 221.04)**

**CAS/DOT #:** 94-75-7/UN2765

**SYNONYMS:** Agrotect, amidox, 2-4-dichlorophenoxyacetic acid, amoxone, tributon, fernimine, herbidal, weed tox.

**PHYSICAL PROPERTIES:** White to yellow crystalline powder; slight phenolic odor, odorless when pure; MP (138°C); BP (160°C); DN (1.416 g/ml); OT (3.13 mg/kg); ST (66.5 dynes/cm at 25°C); VP (53 Pa at 160°C); VD (7.63).

**CHEMICAL PROPERTIES:** Will not polymerize; incompatible with strong oxidizers; FP not available; AT not available; LFL not available; UFL not available

**EXPOSURE ROUTES:** Ingestion (residue on fruits, potatoes and other crops); absorption (contaminated soil); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes and skin; nausea; diarrhea; dysphagia; gastrointestinal distress; vomiting; ventricular fibrillation; Chronic Risks: liver and kidney damage; convulsions; stiffness of extremities; ataxia; paralysis; coma; muscular weakness; mutagenic and teratogenic effects.

**HAZARD RISK:** Combustible; produces hydrogen chloride and carbon monoxide vapors in fire; incompatible with strong oxidizers; capable of creating a dust explosion; decomposition emits toxic fumes of Cl; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; high-pressure liquid chromatography.

**APPLICABLE REGULATIONS:** R3.

**MAJOR USES:** Used for herbicide control on broadleaf plants, grasses, wheat, corn, sugarcane, barley, oats, rice, lawns and turf, non-crop areas pasture and jungle defoliation; plant growth regulator.

**STORAGE:** Keep away from contact with oxidizing materials.

**FIRE FIGHTING:** Use dry chemical foam, carbon dioxide or water.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 10 mg/m<sup>3</sup>; NIOSH REL TWA 10 mg/m<sup>3</sup>; IDLH 100 mg/m<sup>3</sup>

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use dust and splash proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; wear positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; for extra personal protection, a P2 filter respirator for harmful particles should be worn; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; moisten first to prevent dusting; carefully collect remainder, then remove to a safe place.

**HEALTH SYMPTOMS:** inhalation (headache nausea, weakness, irritates skin, eyes and respiratory tract); contact (irritates skin and eyes, burning sensation); ingestion (change in heart rate, coma, convulsions, nausea, vomiting, diarrhea, gastroenteric distress, somnolence, respirator depression, injury to the liver and kidney, dysphagia).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 370 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if swallowed, induce vomiting and follow with gastric lavage and supportive therapy.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

**DDE (C<sub>14</sub>H<sub>8</sub>CL<sub>4</sub>, 318.03)**

**CAS/DOT #:** 72-55-9/UN not available

**SYNONYMS:** 2,2-bis(p-chlorophenyl)-1,1-dichloroethylene.

**PHYSICAL PROPERTIES:** White, crystalline solid; odorless; MP (85°C); VP (6.5E<sup>-6</sup> torr at 20°C); BP (not available); DN (not available).

**CHEMICAL PROPERTIES:** Stable under normal temperatures and pressures; incompatible with oxidizing agents and strong bases; sensitive to light; metabolite of DDT.

**EXPOSURE ROUTES:** Inhalation (release from hazardous waste sites); ingestion (contaminated food); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute and Chronic Risks: possible mutagen, may cause birth defects in future generations.

**HAZARD RISK:** Thermal decomposition and combustion may produce irritating and toxic vapors; incompatible with oxidizing agents and strong bases; hazardous decomposition products include hydrogen chloride, carbon monoxide and carbon dioxide; NFPA code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** C&Sf, CA1; R2; R5.

**MAJOR USES:** Pesticide; insecticide.

**STORAGE:** Store in a cool, dry place; keep container closed.

**FIRE FIGHTING:** Use water, dry chemical, chemical foam or alcohol resistant foam.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV) not established; Short Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) not established.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles; handle only in a chemical fume hood; for respiratory protection, use appropriate OSHA/MSHA approved safety equipment.

**SPILL CLEAN-UP:** Evacuate and ventilate area; wear appropriate equipment; sweep up and place in an appropriate container; hold for proper disposal; wash contaminated surfaces to remove any residues.

**HEALTH SYMPTOMS:** Inhalation (irritates respiratory tract and mucous membranes); eyes/skin (irritation); ingestion (nausea, vomiting, convulsions, loss of consciousness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 880 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide artificial respiration if necessary.

**KEY REFERENCES:** 5; 6; 14; 16.

## DIAZOMETHANE (CH<sub>2</sub>N<sub>2</sub>)

**CAS/DOT #:** 334-88-3/UN not available

**SYNONYMS:** Azimethylene, diazirine.

**PHYSICAL PROPERTIES:** Yellow gas; musty odor; soluble in ether and dioxane; MP (-145°C); BP (-23°C); SG (1.45).

**CHEMICAL PROPERTIES:** Forms yellow solutions in ethereal solvents; decomposition is rapid if alcohols or water is present; FP (not available); AT (100°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of respiratory system and eyes; denudation of mucous membranes; coughing; wheezing; pulmonary edema; chest pains; fulminating pneumonia; weakness; headache; fever; Chronic Risks: tumors; hepatic enlargement.

**HAZARD RISK:** Highly explosive when shocked or exposed to heat or by chemical reaction; undiluted liquid and concentrated solutions may explode violently, especially if impurities are present; may explode on heating to 100°C or on tough glass surfaces; explosive with alkali metals; copper powder causes active decomposition with the evolution of nitrogen and the formation of insoluble white flakes of polymethylene; decomposition emits highly toxic fumes of NO<sub>x</sub>; NFPA code: not available.

**MEASUREMENT METHODS:** Resin adsorption tube; carbon disulfide; gas chromatography.

**APPLICABLE REGULATIONS:** CA2; Sf3; A1; CAL.

**MAJOR USES:** Methylating agent for acidic compounds, carboxylic acids, phenols; analytical reagent.

**STORAGE:** should not be stored; because of its toxicity and its explosive nature, di azomethane is freshly prepared in situ and used in solution of ether or dioxane.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2ppm; OSHA PEL TWA 0.2 ppm (0.4mg/m<sup>3</sup>); NIOSH REL TWA 0.2ppm (0.4mg/m<sup>3</sup>); IDLH 2ppm.

**PERSONAL PROTECTION:** wear a gas-tight suit; wear chemical safety goggles; wear compressed air/oxygen apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; dilute to disperse vapors; if in solution, absorb with noncombustible materials such as dry earth or sand; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (eye irritation, coughing, wheezing, asthma-like symptoms); skin absorption (headache, dizziness, and nausea).

**GENERAL COMMENTS:** First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, drink water and induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

### **DIBENZOFURANS (C<sub>12</sub>H<sub>8</sub>O, 168.20)**

**CAS/DOT #:** 132-64-9/UN not available

**SYNONYMS:** Dibenzofuranne, diphenylene oxide.

**PHYSICAL PROPERTIES:** White crystals or crystalline solid; slightly soluble in alcohol, ether and benzene; MP (83°C, 181°F); BP (154°C, 309°F); DN (1.089 g/ml at 99°C); VF (0.0175 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Stable under normal temperatures and pressures; incompatible with strong oxidizing agents; hazardous polymerization will not occur; FP (130°C); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA group D: not classifiable as to human carcinogenicity; Acute Risks: may cause skin and respiratory tract irritation; Chronic Risks: no information available on humans.

**HAZARD RISK:** Thermal decomposition or combustion may produce irritating and toxic vapors; incompatible with strong oxidizing agents; decomposition emits fumes of carbon monoxide and carbon dioxide; NFPA code: not available

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; R3; R5; Sf3; CAL.

**MAJOR USES:** Insecticide.

**STORAGE:** Keep in a cool, dry, well ventilated area; keep container closed.

**FIRE FIGHTING:** Use water spray, dry chemical, chemical foam or alcohol resistant foam.

**EXPOSURE GUIDELINES:** ACGIH TLV not established; OSHA PEL not established; NIOSH REL not established; IDLH not determined.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including rubber boots and heavy rubber gloves; wear approved chemical safety goggles; mechanical exhaust is required; wear NIOSH/MSHA approved respirator; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Sweep up, place in a bag, and hold for waste disposal; avoid raising dust; ventilate area and wash site after material pickup is complete.

**HEALTH SYMPTOMS:** Inhalation (irritates skin and respiratory system). (Note: The toxicological properties of this chemical have not been thoroughly investigated).

**GENERAL COMMENTS:** First aid: wash eyes immediately with large amount of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 14; 16.

## **1,2-DIBROMO-3-CHLOROPROPANE (C<sub>3</sub>H<sub>5</sub>BR<sub>2</sub>CL, 236.35)**

**CAS/DOT #:** 96-12-8/UN2872

**SYNONYMS:** 1-chloro-2,3-dibromopropane, DBCP, dibromochloropropane, 1,2-dibromo-3-chloropropane, fumazone, nematox.

**PHYSICAL PROPERTIES:** Colorless liquid when pure, commercial grades are amber to dark brown; pungent odor; slightly soluble in water; miscible with oils, dichloropropane and isopropyl alcohol; MP (6.7°C, 44.06°F); BP (195.5°C, 383.9°F); SG (2.05); OT (0.3 ppm); VP (0.8 mm Hg at 21°C).

**CHEMICAL PROPERTIES:** Hazardous polymerization will not occur; incompatible with strong oxidizing agents, bases, aluminum, magnesium, tin and their alloys; FP (76.6°C); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (contaminated air in workplace); ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, mucous membranes, upper respiratory tract and skin; gastrointestinal effects; vomiting; headaches; pulmonary edema; Chronic Risks: effects on liver, eyes, kidneys, CNS and immune system; may alter genetic material; can cause male reproductive effects; known carcinogen.

**HAZARD RISK:** Combustible liquid; heating to decomposition yields hydrogen chloride hydrogen bromide, carbon monoxide and carbon dioxide vapors; NFPA code: H2; F1; R1.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; R2; R3; R4; R5; R7; R8; U waste; Sf1; Sf3; A1; A2; CAL.

**MAJOR USES:** Pesticide; nematocide; soil fumigant; chemical intermediate in the production of organic chemicals.

**STORAGE:** Keep stored in a tightly closed container; store in a cool, dry place, away from heat and open flames.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA not available; OSHA PEL TWA 0.001 ppm (cancer hazard); NIOSH REL TWA 0.01ppm/30M.

**PERSONAL PROTECTION:** use self-contained breathing apparatus if ventilation is poor; wear protective clothing, chemical resistant gloves, boots, safety goggles and face shield;

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; flush remaining residue with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (drowsiness, nausea, vomiting, labored breath).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 170 mg/kg; First aid: wash eyes and skin immediately with large amounts of water for 15 minutes; if inhaled, remove to fresh air and provide respiratory support; if swallowed, drink water.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

### **DIBUTYLPHTHALATE (C<sub>16</sub>H<sub>22</sub>O<sub>4</sub>, 278.38)**

**CAS/DOT #:** 84-74-2/UN3082

**SYNONYMS:** Benzene-o-dicarboxylic acid, dibutyl ester, DBP, phthalate; elaol, 1,2-benzene-dicarboxylate.

**PHYSICAL PROPERTIES:** Colorless, oily liquid; miscible with common organic solvents; MP (-35°C); BP (340°C); SG (1.0484); VD (9.58); VP (1E<sup>-5</sup> mm Hg at 25°C); VS (0.203 poise at 20°C).

**CHEMICAL PROPERTIES:** Can react with oxidizing materials; FP (312°F); AT (750°F); LFL (0.5%); UFL (2.5%).

**EXPOSURE ROUTES:** Inhalation (new cars, air inside homes); ingestion (contaminated food and drinking water); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group D: not classifiable as to human carcinogenicity; Acute Risks: hallucinations; nausea; vomiting; irritation of upper respiratory tract and stomach; Chronic Risks: changes in kidneys, ureter and bladder.

**HAZARD RISK:** Combustible when exposed to heat or flame; can react with oxidizing materials; violent reaction with chlorine; decomposition emits acrid smoke and fumes; NFPA code: H0; F1; R0.

**MEASUREMENT METHODS:** Particulate filter; carbon disulfide; gas chromatography.

**APPLICABLE REGULATIONS:** CA2; R4; U069 (U waste); Sf1; Sf3; A1; CAL.

**MAJOR USES:** Used as a plasticizer for elastomers; explosives; nail polish; solid rocket propellants; nitrocellulose lacquers; used in the manufacture of shower curtains; raincoats; food wraps; bowls; car interiors; safety glass; insecticides; printing inks; paper coatings; adhesives.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical or foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5mg/m<sup>3</sup>; OSHA PEL TWA 5mg/m<sup>3</sup>; NIOSH REL TWA 5mg/m<sup>3</sup>; IDLH 4000mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear chemical-resistant gloves, boots, aprons, etc.; wear chemical safety goggles; wear a NIOSH-approved vapor respirator or other appropriate self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible in dry earth or sand for disposal in a secure sanitary landfill; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, mucous membranes, and upper respiratory tract); eye contact (severe, stinging pain, profuse tears); ingestion (nausea, dizziness, photophobia).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 8000 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, drink water and induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 16.

## 1,4-DICHLOROBENZENE (C<sub>6</sub>H<sub>4</sub>CL<sub>2</sub>, 147.02)

**CAS/DOT #:** 106-46-7/UN1592

**SYNONYMS:** P-dichlorobenzene, dichloricide, PDCB, p-chlorophenyl chloride, para crystals, paradichlorolbenzol, parazene, paramoth, santochlor.

**PHYSICAL PROPERTIES:** Colorless crystals; aromatic, mothball like odor; soluble in chloroform, carbon disulfide, alcohol, ether, acetone and benzene; insoluble in water; MP (53°C, 127°F); BP (174°C, 345°F); DN (1.2475 g/ml); VD (5.07); ST (34.66 dynes/cm at 20°C); VP (1.03 mm Hg at 25°C); OT (0.18 ppm); HV (17.3 kcal/g).

**CHEMICAL PROPERTIES:** Volatile; combustible; non-corrosive; non-staining; reacts strongly with oxidizing agents, aluminum and its alloys; FP (65°C); LFL (1.8%); UFL (7.8%); AT (647°C).

**EXPOSURE ROUTES:** Inhalation (mothballs, toilet deodorizer, emissions from burning); ingestion (contaminating water and foods); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute Risks: irritation of skin, eyes, mucous membranes and upper respiratory tract; Chronic Risks: CNS damage, blood disorders, liver, kidney and lung effects.

**HAZARD RISK:** Combustible; poisonous gases produced when heated; combustion or decomposition products are carbon monoxide, carbon dioxide and hydrogen chloride gas; NFPA Code: H 2 F 2 R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography.

**APPLICABLE REGULATIONS:** CA2; S1; S12; D027 (D waste); U070, U071, U072 (U waste); R3; R1; R5; S1; S3; CW4; CW5; A1.

**MAJOR USES:** Fumigant for moths, molds, mildews, ants, soil, tree boring insects; germicide; used in the manufacture of dyes, pharmaceuticals, mothballs, toilet deodorizer blocks.

**STORAGE:** Keep in a tightly closed container; keep away from heat and open flame; store in a cool, dry place.

**FIRE FIGHTING:** Use dry chemical, foam, carbon dioxide or water spray.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 75ppm; ACGIH TLV STEL 110ppm; OSHA PEL TWA 75ppm (450mg/m<sup>3</sup>); OSHA PEL STEL 110ppm (675 mg/m<sup>3</sup>); NIOSH IDLH 150ppm (6000 mg/m<sup>3</sup>).

**PERSONAL PROTECTION:** wear special protective clothing, i.e., chemical-resistant gloves, boots, aprons, etc.; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** for water spill, apply activated carbon and remove trapped material with suction hoses; for land spill, dig a holding area sealed with an impermeable flexible membrane liner; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and throat); skin absorption (profuse rhinitis, headaches); ingestion (nausea, vomiting, decreased weight).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 500 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with soap and water.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14.

### 3,3'-DICHLOROBENZIDINE (C<sub>12</sub>H<sub>10</sub>CL<sub>2</sub>N<sub>2</sub>, 253.14)

CAS/DOT #: 91-94-1/UN not available

**SYNONYMS:** DCB, dichlorobenzidine base, o,o'-dichlorobenzidine, 3,3'-dichloro-4,4'-diaminobiphenyl.

**PHYSICAL PROPERTIES:** Gray or purple crystalline solid; insoluble in water; soluble in benzene, diethyl ether, ethanol and glacial acetic acid; MP (132°C); BP (402°C); VP ( $1.15 \times 10^{-7}$  mm Hg @ 25°C); SG (not available).

**CHEMICAL PROPERTIES:** Non-flammable; decomposes on heating; formation of diazonium salts and alkyl derivatives; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion (drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA cancer risk level  $8 \times 10^{-5}$  mg/m<sup>3</sup>; EPA group B2: probable human carcinogen; Acute Risks: respiratory tract irritation; coughing; labored breath; blue color; unconsciousness; Chronic Risks: dermatitis; gastrointestinal effects; upper respiratory tract infection; liver injury.

**HAZARD RISK:** Decomposes on heating; decomposition emits toxic and corrosive fumes of nitrogen oxides and hydrogen chloride; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; silicon gel; reagent; high pressure liquid chromatography with ultra violet detection.

**APPLICABLE REGULATIONS:** CA2; U073 (U waste); R4; R5; S1; S3; CW4; CW5; A1.

**MAJOR USES:** Used in the manufacture of azo dyes, rubber and plastic, printing ink, textiles, plastics and crayons; used as a curing agent for polyurethane elastomers, isocyanate containing polymers and solid urethane plastics; used as an intermediate for the detection of gold and production of pigments.

**STORAGE:** Keep in a tightly closed container.

**FIRE FIGHTING:** Use chemical powder, water spray, appropriate foam or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV suspected human carcinogen; OSHA PEL cancer suspect agent; NIOSH REL reduce to lowest feasible level.

**PERSONAL PROTECTION:** wear special protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus; do not eat, drink or smoke in the workplace.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; moisten first to prevent dusting; collect remaining material, then remove to a safe place; this chemical may not enter the environment.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, upper respiratory infection); contact (dermatitis, caustic burns); ingestion (breathing difficult, unconsciousness, blue color).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5250 mg/kg; avoid inhalation of fine dust and mist; First aid: wash eyes immediately with large amounts of water; wash skin with soap and water; remove to fresh air or provide respiratory support; induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

**DICHLOROETHYL ETHER (C<sub>4</sub>H<sub>8</sub>CL<sub>2</sub>O, 143.02)**

**CAS/DOT #:** 111-44-4/UN1916

**SYNONYMS:** Sym-dichloroethyl ether; bis (beta-chloroethyl) ether; chlorex, chloroethyl ether, 2,2'-dichloro-diethylether.

**PHYSICAL PROPERTIES:** Colorless liquid; strong unpleasant odor; insoluble in water; dissolves in oils, fats and greases; MP (-51.9°C, -62°F); BP (178.5°C, 352°F); DN (1.22 g/ml); VP (0.71 mm Hg at 20°C); VD (4.93).

**CHEMICAL PROPERTIES:** Non-flammable; FP (131°F); AT (696°F); LFL (2.7%); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion (groundwater near waste disposal sites); occupational exposure.

**HUMAN HEALTH RISKS:** EPA cancer risk level 3E-6 mg/m<sup>3</sup>; EPA group B2: probable human carcinogen; Acute Risks: irritation of the respiratory tract and skin; congestion; edema; CNS effects; lacrimation; coughing; nausea; vomiting; hemorrhage of the lung; Chronic Risks: no information available for humans.

**HAZARD RISK:** Flammable liquid when exposed to heat, flame or oxidants; dangerous explosion hazard; reacts vigorously with oleum and chlorosulfonic acid; reacts with water or steam to produce toxic and corrosive fumes; can react vigorously with oxidizing materials; combustible liquid; decomposition emits toxic fumes of Cl<sup>-</sup>; NFPA code: H 3; F 2; R 1.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** R3; R5; R7; R8; S1; S3; CW4; CW 5; CAL.

**MAJOR USES:** Used as a solvent for fats, waxes, greases and ester; manufacture of pesticides; cleaning fluid for textiles; purification of oils and gasoline; paints; varnishes.

**STORAGE:** Store in a cool, dry, well ventilated location; store away from heat, oxidizing agents, strong acids and sunlight.

**FIRE FIGHTING:** Use water, foam, mist, fog, spray or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; ACGIH TLV STEL 10 ppm (skin); OSHA PEL TWA 5 ppm; OSHA PEL STEL 10 ppm (skin); NIOSH REL TWA 5 ppm (30 mg/m<sup>3</sup>); NIOSH REL STEL 10 ppm (60mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear special protective clothing and chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, and respiratory system); skin absorption (coughing, nausea and vomiting).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 75 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; remove to fresh air immediately or provide respiratory apparatus; rinse mouth with water and induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

### 1,3-DICHLOROPROPENE (C<sub>3</sub>H<sub>4</sub>CL<sub>2</sub>, 110.97)

**CAS/DOT #:** 542-75-6/UN2047

**SYNONYMS:** 3-chloroallyl chloride, alpha-chloroallyl chloride, 3-chloropropenyl chloride, DCP, telone, vidden-D.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; sweet chloroform like odor; insoluble in water; soluble in acetone, toluene and octane; MP (48°C, 119°F); BP (104°C, 219°F); SG (1.198); VD (3.80); OT (1.0 ppm) VP (34-43 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Oxidizable; reacts strongly with active metals, aluminum, magnesium, halogens and oxidizers; FP (25°C); LFL (5.3%); UFL (14.5%); AT (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); absorption (skin, eyes); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of skin, eyes and respiratory system; hemorrhage of lungs, small intestine and liver; mucous membrane irritation; vomiting; chest pain; emphysema and edema; Chronic Risks: alters genetic material; damage to nasal mucosa and the urinary bladder; effects on eyes, skin, respiratory system, liver and kidneys.

**HAZARD RISK:** Combustible; moderate fire risk; combustion or decomposition products are carbon monoxide, carbon dioxide and hydrogen chloride gas; vapors are heavier than air and may travel to a source of ignition and flash back; NFPA Code: H 2 F3 R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; S1; S3; S12; Sf3; 1A; CW1; CW4; CW5.

**MAJOR USES:** Soil fumigant; organic synthesis.

**STORAGE:** Keep in a tightly closed container; keep away from heat and sparks; store in a cool, dry place.

**FIRE FIGHTING:** Use dry chemical foam, carbon dioxide or water spray.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm (4.5 mg/m<sup>3</sup>); OSHA PEL TWA none; NIOSH REL TWA 1ppm (5 mg/m<sup>3</sup>) (skin), potential occupational carcinogen; IDLH (not determined), carcinogen.

**PERSONAL PROTECTION:** Wear full protective clothing, including vitro® gloves or suits; ployvinyl alcohol (PVA) gloves are also recommended; wear splash-proof safety goggles;

enclose operations and use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** Stop or control leak if possible; collect spilled liquid in sealable containers or absorb with noncombustible materials (e.g., dry earth, sand or vermiculite); remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes, skin, and respiratory system); eyes (corneal burns); skin (skin burns, lacerations); ingestion (headache, dizziness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 470 mg/kg; Personal protection: wear self-contained breathing apparatus; use only in chemical fume hood; First aid: wash eyes immediately with large amounts of water; wash skin immediately with soap and water.

**KEY REFERENCES:** 4; 5; 6; 10; 14; 16.

### **DICHLOROVOS (C<sub>5</sub>H<sub>7</sub>CL<sub>2</sub>O<sub>4</sub>P, 221.0)**

**CAS/DOT #:** 62-73-7/UN2783

**SYNONYMS:** DDVP, 2,2'-dichlorovinyl dimethyl phosphate, bibesol, tetravos, 2,2'-dichloroethanol dimethyl phosphate.

**PHYSICAL PROPERTIES:** Oily, colorless to amber liquid; aromatic, chemical odor; slightly soluble in water and glycerin; miscible with aromatic and chlorinated hydrocarbon solvents and alcohols; MP (not available); BP (140°C); SG (1.415); VP (0.012 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Stable to heat; corrosive to iron and milled steel; FP (116°F); AT (not available); LFL (1.0%); UFL (7%).

**EXPOSURE ROUTES:** Inhalation (indoor air: pest strips, insect sprays); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute Risks: wheezing; pupil constriction; blurred vision; headaches; nausea; cramps; diarrhea; sweating; respiratory failure; anorexia; giddiness; ataxia; rhinorrhea; skin irritation; Chronic Risks: decreased plasma and red blood cholinesterase levels.

**HAZARD RISK:** Hydrogen chloride gas, phosphoric acid mist and carbon monoxide may be released in a fire; corrosive to cast iron, mild steel, brass and stainless steel; decomposition emits toxic fumes of Cl<sup>-</sup> and PO<sub>x</sub>; NFPA code: not available.

**MEASUREMENT METHODS:** 2 XAD tubes in series; toluene; gas chromatography with flame photometric detection for sulfur, nitrogen or phosphorous.

**APPLICABLE REGULATIONS:** CA2; Sf1; Sf2; Sf3; CW1; CW2; A1; CAL.

**MAJOR USES:** Insecticide for crops, outdoor fruits, vegetables, home pest control; ant-helmintic (worming agent) for dogs, swine, horses; botacide (kills larvae) for horses, dogs flea collars.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical or foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (skin); OSHA PEL TWA 1mg/m<sup>3</sup>(skin); NIOSH REL TWA 1 mg/m<sup>3</sup>(skin); IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear special protective clothing, i.e., gas-tight suit, boots, gloves, aprons, etc.; wear chemical safety goggles; use compressed air/oxygen apparatus.

**SPILL CLEAN-UP:** absorb bulk liquids with fly ash or cement powder; dig a pit, pond, lagoon, or holding area to contain liquid; holding areas should be sealed with an impermeable flexible membrane liner.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin); skin absorption (respiratory failure, headache, nausea, giddiness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 17 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; remove to fresh air immediately or provide respiratory apparatus if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

### DIETHANOLAMINE (C<sub>4</sub>H<sub>11</sub>O<sub>2</sub>N, 105.16)

**CAS/DOT #:** 111-42-2/UN not available

**SYNONYMS:** DEA, bis (2-hydroxyethyl) amine, diolamine, 2,2'-dihydroxydiethylamine, 2,2'-iminobisethanol.

**PHYSICAL PROPERTIES:** Faintly colored; viscous liquid or deliquescent prisms; slight ammonia like odor; soluble in water and alcohol; insoluble in ether and benzene; MP (28°C); BP (270°C); OT (0.27 ppm); DN (1.0966 g/mL); VS (351.9 cP at 30°C); VP (0.577 mm Hg at 25°C); VD (3.65).

**CHEMICAL PROPERTIES:** Incompatible with strong acids, acid anhydrides and halides; FP (305°F); AT (1224°F); LFL (1.6%); UFL (10.6%).

**EXPOSURE ROUTES:** Inhalation (use of lubricating liquids in machine building and metallurgy); absorption (through skin from use of shampoos, cosmetics and detergents).

**HUMAN HEALTH RISKS:** Acute Risks: irritation of nose, throat and skin; increased blood pressure; pupillary dilatation; salivation; sedation; inflammation and edema of larynx and bronchi; chemical pneumonitis; pulmonary edema; Chronic Risks: no information available on humans.

**HAZARD RISK:** Combustible when exposed to heat or flame; incompatible with oxidizing agents, copper, copper alloys, zinc, galvanized iron; hazardous decomposition products are carbon dioxide, carbon monoxide and nitrogen oxides; NFPA code: H 1; F 1; R 0.

**MEASUREMENT METHODS:** Impinger; reagent; ion chromatography.

**APPLICABLE REGULATIONS:** CA2; Sf3; T120-a; CAL.

**MAJOR USES:** Used in the production process of lubricants for textiles, organic synthesis, cosmetics, pharmaceuticals, shampoos, cleaners, polishes, gas conditioning agent; used as a chemical intermediate for fatty alkanolamides, liquid detergents, morpholine, rubber chemicals, humectants.

**STORAGE:** Keep in a tightly closed container; store in a cool, dry place.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 mg/m<sup>3</sup> (skin); OSHA PEL none; NIOSH REL TWA 3 ppm (15 mg/m<sup>3</sup>); IDLH not determined.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including butyl rubber gloves and overalls; use chemical safety goggles and/or a full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; use non-sparking tools and equipment; wear self-contained breathing apparatus; since this compound possibly exists in both particulate and vapor phase, a dust/mist prefilter should be used for the particulate; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Ventilate area of leak or spill; collect spilled liquid in sealable containers or absorb with sand or inert material, and place in chemical waste container; flush remainder with large amounts of water, but not into confined spaces such as sewers due to possibility of explosion; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates respiratory tract, sore throat, sneezing, coughing, allergic reaction); skin (redness, allergic reaction, skin burns); eyes (tears, redness, pain, corneal damage); ingestion (irritates mucous membranes, erythema, abdominal pain, nausea, vomiting, diarrhea, blisters or lesions of the mouth, esophagus, or gastro-intestinal tract).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 710 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; remove to fresh air immediately or provide respiratory apparatus if necessary; wash mouth with water.

**KEY REFERENCES:** 4; 5; 6; 10; 14; 16.

### **N,N-DIETHYL ANILINE (C<sub>8</sub>H<sub>11</sub>N, 121.20)**

**CAS/DOT #:** 121-69-7/UN2253

**SYNONYMS:** Benzenamine, N,N-dimethylaniline, N,N-dimethylphenylamine, N-N'-dimethylbenzenamine.

**PHYSICAL PROPERTIES:** Yellow, oily liquid; amine like odor; insoluble in water; miscible with alcohol and ether; MP (1.5-2.5°C, 34.4-35.9°F); BP (193°C, 380°F); DN (0.956 g/ml); OT (0.013 ppm); VD (4.2); ST (35.52 mN/m); VS (1.295E<sup>-3</sup> Pa at 25°C); HV (52.83/kJ/gmol); VP (1 mm Hg at 30°C).

**CHEMICAL PROPERTIES:** Will not polymerize; reacts with acids, acid chlorides, acid anhydrides, oxidizing agents, chloroforms and halogens; FP (145°F); AT (370°C); LFL (1.0%); UFL (6.4%); HC (-4525 kJ/mol).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, mucous membrane and upper respiratory tract; inhibitor of CNS and circulatory systems; headaches; cyanosis; dizziness; paralysis; convulsions; Chronic Risks: blood disorders; changes in CNS, blood and liver; enlargement of spleen; hemosiderosis of liver, kidneys and testes; suspected carcinogen.

**HAZARD RISK:** Dangerous fire hazard; explodes on contact with benzoyl peroxide or diisopropyl peroxydicarbonate; incompatible with acids, acid chlorides, acid anhydrides, chloroformates, halogens and oxidizing agents; thermal decomposition may produce carbon monoxide, carbon dioxide and nitrogen oxides; NFPA Code: H 3 F 2 R 0.

**MEASUREMENT METHODS:** Silicon gel; ethanol; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; Sf3; 1A.

**MAJOR USES:** Manufacture of dyes, vanillin, methyl violet, Michler's ketone; solvent; stabilizer; alkylating agent.

**STORAGE:** Keep in a closed container; store in a cool, dry place, away from heat and open flame.

**FIRE FIGHTING:** Use water, carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; STEL 10 ppm (skin); OSHA PEL TWA 5 ppm (25 mg/m<sup>3</sup>); STEL 10 ppm (skin); NIOSH REL TWA 5 ppm (25 mg/m<sup>3</sup>); STEL 10 ppm (50 mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear appropriate respirator; use safety goggles and face shield; wear long rubber gloves; wear a rubber apron, long sleeves and other protective clothing.

**SPILL CLEAN-UP:** use water spray to reduce vapors; absorb as much as possible with sand or other noncombustible absorbent material and place into container for later disposal; flush area with water; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, mucous membranes); skin absorption (headaches, dizziness, labored breathing, weakness, blood disorders).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1410 mg/kg; First aid: flush eyes and skin for at least 15 minutes while removing contaminated garments and shoes; seek fresh air; provide respiratory support and oxygen; if swallowed wash out mouth with water if conscious.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 16.

## DIETHYL SULFATE ((C<sub>2</sub>H<sub>5</sub>O)<sub>2</sub>SO<sub>2</sub>, 154.20)

**CAS/DOT #:** 64-67-5/UN1594

**SYNONYMS:** Diethyl ester sulfuric acid, diethyl tetraoxosulfate, DS, ethyl sulfate.

**PHYSICAL PROPERTIES:** Colorless, but darkens with age; oily liquid; faint ethereal or peppermint odor; insoluble in water; miscible with alcohol and ether; MP (-25°C, -32°F); BP (209.5°C, 409°F); DN (1.18 g/ml); VP (0.29 mm Hg at 25°C); VD (5.31); VS (1.79 cP at 20°C).

**CHEMICAL PROPERTIES:** Combustible; decomposes in hot water; FP (104.4°C); AT (436°C); LFL (1.4%); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (fugitive emissions); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: destructive to mucous membranes, upper respiratory tract, eyes and skin; pulmonary edema; chemical pneumonitis; laryngitis; coughing; headaches; nausea; spasm of the larynx and bronchi; inflammation and edema of the larynx and bronchi; Chronic Risks: laryngeal cancer.

**HAZARD RISK:** Combustible when exposed to heat or flame; reacts with oxidizing materials; moisture causes liberation of sulfuric acid; rapid decomposition when heated above 100°C; violent reaction with potassium-tert-butoxide; vigorous exothermic hydrolysis when reacted with water in the presence of caustic catalysts at temperatures above 50°C; decomposes at elevated temperature forming ethyl ether, which is more flammable than the material itself; decomposition emits toxic fumes of SO<sub>x</sub>; NFPA code: H 3; F 1; R 1.

**MEASUREMENT METHODS:** Not available

**APPLICABLE REGULATIONS:** CA2; Sf3; CAL.

**MAJOR USES:** Ethylating agent; accelerator in sulfation of ethylene; alkylating agent; used as a chemical intermediate for ethyl derivatives of phenols, amines and thiols.

**STORAGE:** Keep in a tightly closed container; store away from heat and open flame, in a cool, dry place.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** DFG TRK 0.03 ppm, animal carcinogen, possible human carcinogen.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Stop or control leak if possible; use water spray to cool and disperse vapors; absorb liquid in noncombustible materials (e.g., dry earth, sand or vermiculite), and place in chemical waste container.

**HEALTH SYMPTOMS:** Inhalation (coughing, wheezing, shortness of breath, headache, nausea, vomiting, laryngitis, inflammation and edema of larynx and bronchi); skin/eyes (severe eye and skin burns).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 880 mg/kg; Personal protection: use self-contained breathing apparatus and wear protective clothing; First aid: wash eyes and skin immediately with large amounts of water; remove to fresh air immediately or provide respiratory apparatus if necessary; wash mouth with water.

**KEY REFERENCES:** 10; 14; 16.

**3,3'-DIMETHOXYBENZIDINE ([C<sub>6</sub>H<sub>3</sub>(OCH<sub>3</sub>)NH<sub>2</sub>]<sub>2</sub>, 244.32)**

**CAS/DOT #:** 119-90-4/UN not available

**SYNONYMS:** Acetamine diazo black RD, azoene fast blue base, spectrolene blue B, setacyl diazo navy R, diacelliton fast grey G; 3,3'-dimethoxybenzidine, o-dianisidine.

**PHYSICAL PROPERTIES:** Colorless, crystalline solid; turns violet when exposed to air; soluble in alcohol and ether; insoluble in water; MP (137°C); BP (not available); VP (8.8E<sup>-9</sup> mm Hg at 25°C); VD (8.5); SG (not available).

**CHEMICAL PROPERTIES:** Incompatible with strong oxidizers; will not polymerize; FP (206°C); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Home use of packaged dyes and pigments; occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute Risks: irritation to skin and eyes; Chronic Risks: weight loss; effects on liver, kidneys and bladder; intestinal hemorrhage; tumors of mammary gland, ovary, bladder, intestine, skin and stomach.

**HAZARD RISK:** Combustible when exposed to heat or flame; combustion produces emissions of carbon monoxide, carbon dioxide and nitrogen oxides; capable of creating dust explosions; incompatible with strong oxidizers; decomposition emits toxic fumes of NO<sub>x</sub>; NFPA code: H2; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter; water; high pressure liquid chromatography with ultra violet detection.

**APPLICABLE REGULATIONS:** CA2; R4; U091 (U waste); Sf1; Sf3; CAL.

**MAJOR USES:** Used as an intermediate in the production of dyes, pigments and azo dyes.

**STORAGE:** Keep away from contact with oxidizing materials.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV not applicable; OSHA PEL reduce to lowest feasible level, potential occupational carcinogen; NIOSH REL reduce to lowest feasible level, potential occupational carcinogen; IDLH not determined, potential occupational carcinogen.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including rubber boots, heavy rubber gloves, and disposable coveralls; chemical-resistant gloves are required; wear chemical safety goggles; use only in a chemical fume hood; wear self-contained breathing apparatus operated in positive pressure mode; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Sweep up, place in a bag and hold for waste disposal; ventilate area and wash spill site after material pickup is complete.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes and skin, irritates mucous membranes and upper respiratory tract, sneezing); skin (irritation or allergic reaction); ingestion (thyroid, spleen changes).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1920 mg/kg; Personal protection: wear self-contained breathing apparatus and protective clothing and goggles; First aid: wash eyes and skin immediately with large amounts of water; remove to fresh air or provide respiratory support; induce vomiting.

**KEY REFERENCES:** 4; 5; 6; 10; 14; 16.

### **DIMETHYL AMINOAZOBENZENE (C<sub>14</sub>H<sub>15</sub>N<sub>3</sub>, 25.30)**

**CAS/DOT #:** 60-11-7/UN not available

**SYNONYMS:** Methyl yellow, benzeneamine, atul fast yellow, N,N-dimethyl-4-aminoazobezene, DAB, brilliant fast spirit yellow, para-dimethylaminoazobenzene, N,N-dimethyl-p-azoaniline, butter yellow.

**PHYSICAL PROPERTIES:** Yellowish, crystalline leaflets; aromatic, chloroform like odor; insoluble in water; MP (111°C); BP (sublimes); SG (1.05); VP (3.3E<sup>-7</sup> mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Will not polymerize; incompatible with strong acids and strong oxidizing agents; FP (not available); AT(not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure

**HUMAN HEALTH RISKS:** Acute Risks: irritation of skin, causing a rash or burning feeling; Chronic Risks: liver and bladder effects; may damage developing fetus; probable cancer causing agent.

**HAZARD RISK:** Noncombustible solid; contact with strong oxidizers may cause fire; decomposition emits carbon monoxide, carbon dioxide and nitrogen oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Gas chromatography P tube; 2-propanol; gas chromatography

**APPLICABLE REGULATIONS:** SF3; A1; A4.

**MAJOR USES:** Coloring polishes; wax products; polystyrene; soap; indicators.

**STORAGE:** Keep in tightly closed container; store in a cool, dry, well-ventilated area.

**FIRE FIGHTING:** Use water spray, alcohol foam, dry chemical or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV not established; OSHA PEL TWA potential occupational carcinogen; NIOSH REL TWA potential occupational carcinogen; IDLH not established, carcinogen.

**PERSONAL PROTECTION:** Wear a protective suit and heavy, rubber gloves; use approved chemical safety goggles; should be handled only in a chemical fume hood; on approved self-contained breathing apparatus with a full facepiece operated in positive pressure mode is recommended.

**SPILL CLEAN-UP:** Evacuate area; wear appropriate OSHA regulated equipment; ventilate area of spill; sweep up and place in an appropriate container; hold for proper disposal; wash contaminated surfaces to remove any residues; liquid containing this substance may be absorbed in dry earth, sand or vermiculite.

**HEALTH SYMPTOMS:** Inhalation (coughing, wheezing, shortness of breath); skin (contact dermatitis, skin sensitization); ingestion (bronchial secretions, frequent urination, bloody sputum, blood in urine).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 200 mg/kg; First aid: flush eyes immediately with water for 15 minutes, occasionally lifting upper and lower lids; remove contaminated clothing; immediately wash skin with large amounts of soap and water.

**KEY REFERENCES:** 4; 5; 6; 14; 16.

### **3,3'-DIMETHYL BENZIDINE ([-C<sub>6</sub>H<sub>3</sub>(CH<sub>3</sub>)-4-NH<sub>2</sub>]<sub>2</sub>, 212.32)**

**CAS/DOT #:** 119-93-7/UN not available

**SYNONYMS:** Bianzidine; 4,4'-diamino-3,3'-dimethylbiphenyl; 2-tolidine, 4,4'-di-*o*-toluene, diaminoditoly, *o*-tolidine, 3,3'-tolidine, 3,3'-dimethylbenzidine.

**PHYSICAL PROPERTIES:** White to red crystalline solid; darkens on exposure to air; slightly soluble in water; soluble in alcohol and ether; MP (130°C); BP (572°F); SG (not available); VP (1.7E<sup>-4</sup> mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Polymerization will not occur; incompatible with strong oxidizers; FP (not available); AT(not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation and skin absorption (home use of dyes and pigments); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute Risks: irritation of eyes, nose, throat; loss of balance; dizziness; confusion; Chronic Risks: tumors of intestines, skin, lung and liver; CNS effects.

**HAZARD RISK:** Combustible; capable of creating dust explosions; incompatible with strong oxidizers; combustion will produce carbon dioxide, carbon monoxide and oxides of nitrogen; decomposition emits toxic fumes of NO<sub>x</sub>; affected by light; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; water; high pressure liquid chromatography with ultra violet detection.

**APPLICABLE REGULATIONS:** CA2; R3; R4; R5; U095 (U waste); Sf1; Sf3; CAL.

**MAJOR USES:** Used as an intermediate for dyes and pigments; used as a sensitive reagent for gold and free chlorine in water; curing agent for urethane resins.

**STORAGE:** Keep away from contact with oxidizing materials.

**FIRE FIGHTING:** Use dry chemical, water spray or mist or carbon dioxide.

**EXPOSURE GUIDELINES:** Sweep spilled substance into sealable containers; use wet vacuuming or moisten first to prevent dusting; collect remaining material, then remove to a safe place.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles or face shield, in combination with breathing protection; use a closed system of local exhaust ventilation at site of chemical release; for extra personal protection, wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable containers; use wet vacuuming or moisten first to prevent dusting; collect remaining material, then remove to a safe place.

**HEALTH SYMPTOMS:** Inhalation (cough, dizziness, irritates eyes and nose).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 404 mg/kg; Personal protection: wear self-contained breathing apparatus, protective clothing and goggles; First aid: wash eyes and skin immediately with large amounts of water; remove to fresh air or provide respiratory support; induce vomiting.

**KEY REFERENCES:** 4; 5; 6; 14; 16

### **DIMETHYL CARBAMOYL CHLORIDE (C<sub>3</sub>HC<sub>6</sub>INO, 107.54)**

**CAS/DOT #:** 79-44-7/UN2262

**SYNONYMS:** Carbamic acid; carbamyl chloride; chloroformic acid dimethylamide, dimethylcarbamic chloride, dimethylchloroformide.

**PHYSICAL PROPERTIES:** Colorless liquid; MP (-33°C, -27°F); BP (167°C, 333°F); SG (1.168); VD (3.73).

**CHEMICAL PROPERTIES:** Combustible; reacts strongly with oxidizing agents and strong bases; decomposes on exposure to moist air or water; FP (68°C); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute Risks: skin irritation; damage to mucous membranes of nose throat and lungs; conjunctivitis; keratitis; Chronic Risks: alters genetic material; local sarcomas; liver disturbance; skin tumors.

**HAZARD RISK:** Incompatible with oxidizing agents and strong bases; NFPA Code: not available

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; U097 (U waste); Sf1; Sf3.

**MAJOR USES:** Chemical intermediate for pharmaceuticals, pesticides and dye synthesis.

**STORAGE:** Keep in a tightly closed container; keep away from heat and open flame; store in a cool, dry place.

**FIRE FIGHTING:** Use dry chemical foam or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (40 mg/m), suspected human carcinogen; OSHA PEL none; NIOSH REL reduce to lowest feasible concentration, potential occupational carcinogen; IDLH not determined, potential occupational carcinogen.

**PERSONAL PROTECTION:** Wear Tyvek7-type disposable protective clothing during handling of this chemical, including Tyvek7-type sleeves taped to gloves; wear splash-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use a NIOSH-approved supplied air respirator with a full face piece or self-contained breathing apparatus; provide eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Use absorbent paper to pick up small liquid spills; absorbent paper should be sealed in a vapor-tight plastic bag for eventual disposal; absorb large liquid spills in dry earth, sand or vermiculite, and deposit in sealed containers; wash all contaminated surfaces with 60 - 70% ethanol followed by washing with a soap and water solution; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (wheezing, coughing, shortness of breath, irritates eyes, nose and throat), skin (severe irritation, skin burns); eyes (irritates and inflames eyes, possible permanent damage); ingestion (headache, nausea, vomiting, laryngitis, liver injury).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1 g/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; remove to fresh air or provide respiratory support if necessary.

**KEY REFERENCES:** 14; 16

## **DIMETHYL FORMAMIDE (C<sub>3</sub>H<sub>7</sub>ON, 73.11)**

**CAS/DOT #:** 68-12-2/UN2265

**SYNONYMS:** N-N-dimethyl formamide, DMF, N-formyldimethylamine.

**PHYSICAL PROPERTIES:** Colorless to slightly yellow hygroscopic liquid; fishy, unpleasant odor; MP (-61°C); BP (152.8°C); DN (0.945 g/ml); VP (3.7 mm Hg at 25°C); VD (2.51).

**CHEMICAL PROPERTIES:** Incompatible with carbon tetrachloride, strong oxidizers, alkyl aluminums, inorganic nitrates and other halogenated compounds; FP (136°C); AT (833°F); LFL (2.2%); UFL (15.2%).

**EXPOSURE ROUTES:** Occupational exposure; effluents from sewage treatment plants and industrial plants.

**HUMAN HEALTH RISKS:** Acute Risks: abdominal pain; nausea; vomiting; rashes; jaundice; dermatitis; skin and eye irritation; Chronic Risks: damage to kidneys and liver; minimal hepatic changes; digestive disturbances; cancers of the buccal cavity or pharynx.

**HAZARD RISK:** Flammable liquid when exposed to heat or flame; can react with oxidizing materials; explosion hazard when exposed to flame; avoid contact with halogenated hydrocarbons, inorganic and organic nitrates; ignition on contact with chromium trioxide; forms

explosive mixtures with lithium azide and uranium perchlorate; decomposition emits toxic fumes of NO<sub>x</sub>; NFPA code: H 1; F 2; R 0.

**MEASUREMENT METHODS:** Silicon gel; methanol; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** Sfl.

**MAJOR USES:** Industrial solvent for vinyl resins, butadiene, acid gases, polyacrylic fibers; used in the production of polymer fibers, films, surface coatings, wire enamels; catalyst in carboxylation reactions; crystallization medium in pharmaceutical industry.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use foam, carbon dioxide or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm (skin); OSHA PEL TWA 10ppm (30mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10ppm (30mg/m<sup>3</sup>) (skin); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear a gas-tight suit; wear chemical safety goggles; wear compressed air/oxygen apparatus.

**SPILL CLEAN-UP:** use water spray to reduce vapors; take up with sand or other non-combustible absorbent material and place into container for later disposal; flush area with large amounts of water; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin contact (nausea, vomiting, headache, loss of appetite, defatting of skin, facial flushing); eye contact (irritation, redness, burning, tears).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2800 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; remove to fresh air immediately or provide respiratory apparatus if necessary; drink water and induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

### 1,1-DIMETHYL HYDRAZINE (C<sub>2</sub>H<sub>8</sub>N<sub>2</sub>, 60.12)

**CAS/DOT #:** 57-14-7/UN1163

**SYNONYMS:** Unsymmetrical dimethyl hydrazine; UMDH; dimazine; dimethylhydrazine, N-N'-dimethylhydrazine.

**PHYSICAL PROPERTIES:** Colorless liquid, turns yellow upon contact with air; soluble in water; miscible with ethanol, dimethylformamide and hydrocarbons; MP (58°C, 136.4°F); BP (63.9°C, 147.0°F); DN (0.782 g/ml); SG (0.78); VD (1.94); OT (1.7 ppm); VP (103 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Hazardous polymerization will not occur; powerful reducing agent; incompatible with copper, copper alloys, brass, iron and iron salts; FP (-1.1°C); AT (247°C); LFL (2%); UFL (95%).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; exposure to ambient air where jet or rocket fuel is used.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of nose and throat; burning sensation; coughing; shortness of breath; headaches; conjunctivitis; corrosive to skin; Chronic Risks: liver damage; may alter genetic material; gastrointestinal effects.

**HAZARD RISK:** Dangerous fire hazard; vapor may cause flashback by traveling to ignition source; decomposition emits carbon monoxide, carbon dioxide and nitrogen oxides; flammable upon exposure to air; spontaneously ignites with many oxidants; incompatible with copper, copper alloys, brass, iron and iron salts; avoid contact with water due to liberation of heat; NFPA code: H 4; F 3; R 1.

**MEASUREMENT METHODS:** Bubbler containing hydrogen chloride; colorimetric spectroscopy; phosphomolybdic acid.

**APPLICABLE REGULATIONS:** CAA; A5; CAL.

**MAJOR USES:** Plant growth control agent; basis as a fuel; absorbent for acid gases; used in photography.

**STORAGE:** Store under nitrogen in a tightly sealed container; keep away from combustible materials and ignition sources.

**FIRE FIGHTING:** Use alcohol foam, carbon dioxide or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (skin); OHA PEL TWA 0.5 ppm ( $1\text{mg}/\text{m}^3$ )(skin); NIOSH REL TWA 0.15  $\text{mg}/\text{m}^3/2\text{H}$ ; IDLH 15 ppm.

**PERSONAL PROTECTION:** wear boots, apron chemical-resistant gloves, and chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; absorb as much as possible with noncombustible materials such as dry earth or sand; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (nose and throat irritation, mild conjunctivitis, headache, nausea, vomiting, shortness of breath); skin absorption (irritates skin, eyes, and mucous membranes, causes skin burns).

**GENERAL COMMENTS:** Oral rat  $\text{LD}_{50}$  122  $\text{mg}/\text{kg}$ ; First aid: remove to fresh air and give artificial respiration if necessary; flush eyes with large amounts of water for 15 minutes; wash skin with large amounts of soap and water for 15 minutes; remove clothing; do not induce vomiting; drink water if conscious.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

## **DIMETHYLPHTHALATE ( $\text{C}_{10}\text{H}_{10}\text{O}_4$ , 194.20)**

**CAS/DOT #:** 131-11-3/UN9188

**SYNONYMS:** DMP; avolin; 1,2-benzenedicarboxylic acid, methyl phthalate, phthalic acid methyl ester, solvarone, dimethyl benzeneorthodicarboxylate.

**PHYSICAL PROPERTIES:** Colorless, oily liquid; slightly sweet odor; miscible with alcohol and ether; insoluble in water and paraffinic hydrocarbons; MP (0°C); BP (282.4°C); SG (1.19); VP ( $4.19 \times 10^{-3}$  mm Hg at 20°C); VD (6.69); VS (17.2 cP at 25 °C).

**CHEMICAL PROPERTIES:** Incompatible with nitrates, alkalis, oxidizing agents and acids; FP (149°C); AT (555°C); HC (119.7 kcal/mole); LFL (0.94%); UFL (8.03%).

**EXPOSURE ROUTES:** Ingestion (food, drinking water); use of hemodialysis tubing; polyvinylchloride bags containing intravenous solutions; occupational exposure; not absorbed through skin.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, nose and throat; CNS depression; Chronic Risks: no information available on humans.

**HAZARD RISK:** Combustible when exposed to heat or flame; can react with oxidizing materials; hazardous decomposition products are carbon monoxide and carbon dioxide; combustion emits acrid smoke and irritating fumes; NFPA code: H 0; F 1; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; R3; R4; R5; R9; U102 (U waste); Sf1; Sf3; CW4; CW5; A1; CAL.

**MAJOR USES:** Used in the manufacture of solid rocket propellants; lacquers; plastics; resins; safety glasses; rubber coating agents; molding powders; insect repellants; pesticides; solvent and plasticizer for cellulose acetate and cellulose acetate butyrate compositions.

**STORAGE:** Keep in a tightly closed container; store in a cool, dry place.

**FIRE FIGHTING:** Use carbon dioxide or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; IDLH 2000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear special protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb liquid with non-combustible materials (e.g., dry earth, sand or vermiculite), and place in chemical waste containers; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and mucous membranes); ingestion (central nervous system depression, headache, nausea, vomiting, burning sensation).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 6800 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; remove to fresh air immediately or provide respiratory apparatus if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

**DIMETHYL SULFATE (C<sub>2</sub>H<sub>6</sub>O<sub>4</sub>S, 126.14)****CAS/DOT #:** 77-78-1/UN1595**SYNONYMS:** Methyl sulfate, dimethyl ester.**PHYSICAL PROPERTIES:** Colorless, oily liquid; faint onion like odor; slightly soluble in water, hexane and benzene; MP (-31.8°C); BP (188°C); DN (1.322); VD (4.35); VP (0.5 mm Hg at 20°C).**CHEMICAL PROPERTIES:** Combustible; incompatible with strong oxidizing agents, strong bases and ammonia; FP (83.3°C); AT (494°C); LFL (3.6%); UFL (23.3%).**EXPOSURE ROUTES:** Inhalation (ambient air near coal fired generating plants, fly ash generated by coal combustion processes); occupational exposure.**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute Risks: inflammation and necrosis of the eyes, mouth and respiratory tract; ulceration; delirium; coma; severe blistering; conjunctivitis; catarrhal inflammation of the mucous membranes, nose, throat, larynx and trachea; Chronic Risks: damage to the lungs, liver, kidneys, heart and CNS; prostration; suppression of urine; pulmonary edema; jaundice; hematuria; albuminuria.**HAZARD RISK:** Flammable when exposed to heat, flame or oxidizers; can react with oxidizing materials; may decompose on exposure to water or moist air; hazardous decomposition products are carbon monoxide, carbon dioxide and sulfur oxides; decomposition emits toxic fumes of SO<sub>x</sub>; NFPA code: H 4; F 2; R 0.**MEASUREMENT METHODS:** Not available.**APPLICABLE REGULATIONS:** CA2; R4; U103 (U waste); Sf1; Sf2; Sf3; T30; T120-d; CAL.**MAJOR USES:** Used in the manufacture of organic chemical, dyes, perfumes, war gas, polyurethane based adhesives; separation of mineral oils; analysis of auto fluids; methylating agent for amines and phenols.**STORAGE:** Keep in a tightly closed container, away from heat and open flame.**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (skin); OSHA PEL TWA 0.1 ppm (skin); NIOSH REL TWA 0.1 ppm (0.5mg/m<sup>3</sup>)(skin); IDLH 7 ppm.**PERSONAL PROTECTION:** wear special protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; prompt cleanup and removal are necessary.**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, nose, throat, larynx, and trachea); contact (skin ulcerations, necrosis, reddening of the skin).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 205 mg/kg; Personal protection: use self-contained breathing apparatus; wear protective clothing; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 4; 4b; 10; 14; 16.

#### **4,6-DINITRO-O-CRESOL and SALTS (C<sub>7</sub>H<sub>6</sub>O<sub>5</sub>N, 198.13)**

**CAS/DOT #:** 534-52-1/UN1598

**SYNONYMS:** Antinonin, arborol, detal, dillex, dinitro-dendtroxal, elgetol, DNOC, methyl-2,4-dinitrophenol (6-), raphatox, rafex, sandolin, sinox, winterwash.

**PHYSICAL PROPERTIES:** Yellow, prismatic solid; sodium salt is a red powder; soluble in alkaline aqueous solutions; slightly to freely soluble in water; MP (87.5°C); BP (312°C); SG (1.1); VP (1.05E<sup>-4</sup> mm Hg at 25°C); VD (6.82).

**CHEMICAL PROPERTIES:** Will not polymerize; incompatible with strong oxidizers; AT (435°C); HC (-3920 cal/g)

**EXPOSURE ROUTES:** Inhalation, ingestion (contaminated water from industrial effluents and pesticide leachate runoff); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TCl<sub>o</sub> 1 mg/m<sup>3</sup>; Acute Risks: profuse sweating; rapid respiration; fatigue; lethargy; headache; nausea; appetite loss; collapse; local necrosis; irritation of eyes and skin; jaundice; Chronic Risks: chest pain; liver and kidney damage; effects to cardiovascular, gastrointestinal and CNS; changes in blood count; weight loss; hyperglycemia; hyperpyrexia; glycosuria; decreased liver enzyme activity; blindness; dermal necrosis.

**HAZARD RISK:** May detonate in a fire; usually moistened with 10% water to reduce the risk of explosion; combustion will produce carbon dioxide, carbon monoxide and nitrogen oxides; incompatible with strong oxidizers; NFPA code: not available.

**MEASUREMENT METHODS:** Particulate filter; bubbler; 2-propanol; high pressure liquid chromatography with ultraviolet detection.

**APPLICABLE REGULATIONS:** CA2; F6; R4; P047 (P waste); Sf1; Sf2.

**MAJOR USES:** Insecticide; herbicide; fungicide; free radical polymerization inhibitor; used in emulsifiable concentrate formulations; used in the dyestuff industry.

**STORAGE:** Keep away from contact with oxidizing materials and away from fire.

**FIRE FIGHTING:** Use water, foam, dry chemical or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.3 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.2 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.2 mg/m<sup>3</sup>; IDLH 5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear protective clothing and chemical resistant gloves; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** liquid formulations may be reduced to solid phase by evaporation; remove solids by vacuum cleaning or by dissolving them in water or other solvent; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin, shortness of breath); skin absorption (headache, nausea, profuse sweating); ingestion (excessive thirst).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 10 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

## **2,4-DINITROPHENOL (C<sub>6</sub>H<sub>4</sub>N<sub>2</sub>O<sub>5</sub>, 184.12)**

**CAS/DOT #:** 51-28-5/UN1320

**SYNONYMS:** Aldifen, fenoxyl carbon, 2,4-DNP, tertrosulphur black PB, alpha-dinitrophenol, solfo black B, hydroxy-2,4-dinitrobenzene.

**PHYSICAL PROPERTIES:** Yellow crystals; volatile with steam; slightly soluble in water; soluble in benzene; MP (112°C, 233.6°F); BP (sublimes); DN (1.683 at 24 °C); VD (6.35); VP (1.42E-7 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Sublimes when heated; forms explosive salts with alkalis and ammonia; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (vapors); ingestion (contaminated water from pesticide runoff); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA RfD 0.002 mg/kg/d; Acute Risks: nausea; vomiting; sweating; dizziness; headaches; weight loss; fatigue; weakness; rapid breathing; tachycardia; rise in body temperature; rapid metabolism and excretion; Chronic Risks: cataracts; skin lesions; effect on bone marrow, CNS and cardiovascular system; polyneuropathy; fetal growth inhibition; exfoliative.

**HAZARD RISK:** Explosive; forms explosive salts with alkalis and ammonia; decomposition emits toxic fumes of NO<sub>x</sub>; may explode when shocked or exposed to heat or chemical; NFPA code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; S3; R4; R5; R6; P048 (P waste); Sf1; Sf3; CW1; CW4; CW5; T120-d; CAL.

**MAJOR USES:** Used as an intermediate in the manufacture of wood preservatives, dyes, pesticides, fungicides and miticides; used as an indicator for the detection of potassium and ammonium ions.

**STORAGE:** Keep in a cool, well ventilated place; keep away from heat, ignition sources and sun rays.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; Short-Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including rubber gloves, lab coat, apron or coveralls; wear chemical safety goggles or face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; use self-contained breathing apparatus operated in positive pressure mode; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN UP:** Evacuate danger area; because of its explosive properties, not allow to dry out; sweep spilled substance into sealable containers; wipe up remainder in sand or other inert material.

**HEALTH SYMPTOMS:** Inhalation (headache, dizziness, rapid breathing, fatigue, weakness) skin (redness, roughness, yellow staining of skin), eyes (cataracts); ingestion (nausea, vomiting, palpitations, collapse, sweating).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 30 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 5; 6; 4; 16.

## **2,4-DINITROTOLUENE (C<sub>7</sub>H<sub>6</sub>N<sub>2</sub>O<sub>4</sub>, 182.15)**

**CAS/DOT #:** 121-14-2/UN1600

**SYNONYMS:** 1-methyl-2,4-dintro, dichloro-4-hydroxybenzene(1,3-), dinitrotoluene(2,4-), methyl-1,3-dinitrobenzene.

**PHYSICAL PROPERTIES:** Slightly yellow, sharp crystals; soluble in alcohol and ether; moderately soluble in water; MP (66-68°C); BP (300°C); VP (0.0051 mm Hg at 20°C); SG (1.3208).

**CHEMICAL PROPERTIES:** Generally stable under normal temperature and pressure; reacts with oxidizing agents, reducing agents and strong bases; ignites on contact with sodium oxide; combustible when exposed to heat or flame; FP (404°C); AT (420°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Acute Risks: headaches; dizziness; weakness; appetite loss; nausea; metallic taste in mouth; tremors; Chronic Risks: insomnia; tingling pains in extremities; methemoglobinemia; cyanosis; anemia; heart disease; convulsions; ataxia; paralysis; renal and liver tumors; testicular atrophy.

**HAZARD RISK:** Combustible when exposed to heat or flame; reacts with oxidizing materials, reducing agents and strong bases; instances of explosion during manufacture or storage; explosive when mixed with nitric acid; ignites on contact with sodium oxide decomposition

emits toxic fumes of NO<sub>x</sub>; mixture with sodium carbonate decomposes with significant pressure increase at 210°C; NFPA code: H 3; F 1; R 3.

**MEASUREMENT METHODS:** Particulate filter; gas chromatography with thermal energy analyzer detection and explosives package.

**APPLICABLE REGULATIONS:** CA2; S3; R4; R5; R7; R8; D030 (D waste); U105 (U waste); Sf1; Sf3; CW4; CW5; T30; T120-d; CAL.

**MAJOR USES:** Used as an intermediate in the manufacture of polyurethanes, toluidines, dyes, explosives, smokeless gunpowders; used for organic synthesis.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use dry chemical, water spray, chemical or alcohol resistant foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1.5 mg/m<sup>3</sup>; (skin); OSHA PEL TWA 1.5 mg/m<sup>3</sup>; NIOSH REL TWA 1.5 mg/m<sup>3</sup>; IDLH (no data found).

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use dust explosion-proof electrical equipment and lighting; for extra personal protection, chemical protection suit including self-contained breathing apparatus is recommended.

**SPILL CLEAN-UP:** Sweep spilled solid and place in steel drum for removal; moisten first to prevent dusting; flush area with hot water to remove solid, but not into confined spaces such as sewers due to possibility of explosion; cool and settle solid for proper disposal.

**HEALTH SYMPTOMS:** Inhalation (headache, dizziness, nausea, confusion, convulsions, blue skin, blue lips or fingernails, unconsciousness); skin (severe skin burns); eyes (redness, severe corneal burns); ingestion (appetite loss, nausea, headache, insomnia, muscular weakness, dizziness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 268 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide artificial respiration if necessary.

**KEY REFERENCES:** 4; 5; 6; 10; 14; 16.

### **1,4-DIOXANE (C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>, 88.11)**

**CAS/DOT #:** 123-91-1/UN1165

**SYNONYMS:** Diethylene dioxide, diethylene ether, dioxane, tetrahydro-1,4-dioxin, 1,4-dioxacyclohexane, oxyethylene ether.

**PHYSICAL PROPERTIES:** Colorless liquid; faint, pleasant odor; soluble in water and organic solvents; MP (11.8°C, 53.2°F); BP (101.0°C, 214°F); SG (1.0329); VP (27 mm Hg at 20°C); OT (24 ppm); VS (0.0120 cP at 25 °C).

**CHEMICAL PROPERTIES:** Flammable liquid; incompatible with strong oxidizers, halogens and reducing agents; can form explosive peroxides; attacks many plastics; AT (356°C); FP (12°C); HC (581 kcal/mol); LFL (2.0%); UFL (22%).

**EXPOSURE ROUTES:** Ingestion (contaminated drinking water); occupational exposure.

**HUMAN HEALTH RISKS:** EPA group B2: probable human carcinogen; Inhalation human TLo 470 ppm; Acute Risks: irritation of skin, eyes, nasal passages, throat and lungs; dizziness; headaches; nausea; coughing; abdominal pain; vomiting; drowsiness; Chronic Risks: effects on kidneys, liver and CNS; may alter genetic material; hepatic and renal lesions.

**HAZARD RISK:** Dangerous fire hazard; incompatible with strong oxidizers, halogens, reducing agents, heat and moisture; forms explosive peroxides; decomposition emits carbon monoxide and carbon dioxide; vapors are heavier than air and may travel to distant ignition sources and flash back; NFPA code: H 2; F 3; R 1.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; P waste; R5; R7; Sf1; Sf3; A1; CAL.

**MAJOR USES:** Used as an industrial solvent for cellulose acetate, ethyl cellulose, benzyl cellulose, oils, resins, waxes, dyes, other organic and inorganic compounds; used as a stabilizer in chlorinated solvents.

**STORAGE:** Keep in a cool, dry place, away from heat or flame; store away from strong oxidants and strong acids; keep in the dark; store only if stabilized.

**FIRE FIGHTING:** Use chemical powder, alcohol resistant foam, water spray or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm (90mg/m<sup>3</sup>)(skin); OSHA PEL TWA 100 ppm (360mg/m<sup>3</sup>)(skin); NIOSH REL TWA 1 ppm/30M (3.6mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, i.e., chemical-resistant rubber gloves, rubber boots, aprons, etc.; wear splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; cover spill with activated carbon adsorbent; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (headache, nausea, drowsiness); ingestion (vomiting, liver damage, kidney failure).

**GENERAL COMMENTS:** First aid: flush eyes or skin with large amounts of water for at least fifteen minutes; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, wash out mouth if person is still conscious.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

**1,2-DIPHENYLHYDRAZINE (C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>, 184.26)**

**CAS/DOT #:** 122-66-7/UN not available

**SYNONYMS:** N,N'-bianiline; N,N'-diphenylhydrazine; hydrozodi-benzene, (sym)-diphenylhydrazine; hydrazobenzene.

**PHYSICAL PROPERTIES:** Orange-yellow, crystalline solid; slightly soluble in water; insoluble in acetylene; decomposes at boiling point; MP (126-127°C, 260°F); BP (not available); SG (1.58).

**CHEMICAL PROPERTIES:** Non-flammable solid; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); occupational exposure.

**HUMAN HEALTH RISKS:** EPA cancer risk level 5.0E-6 mg/m<sup>3</sup>; EPA group B2: probable human carcinogen; Acute Risks: respiratory tract irritation; coughing; Chronic Risks: may alter genetic material; possible carcinogen.

**HAZARD RISK:** Incompatible with strong oxidizers, strong acids, acid chlorides and acid anhydrides; combustion products are carbon monoxide, carbon dioxide and nitrogen oxide; decomposes on heating or burning; reacts with NFPA code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; S3; R4; R5; R8; U109 (U waste); Sf1; Sf3; CW4; CW5; CAL.

**MAJOR USES:** Used in the manufacture of benzidine, benzidine based drugs and anti-inflammatory drugs.

**STORAGE:** Keep in a cool, dark, dry, well ventilated room; store under inert gas.

**FIRE FIGHTING:** Use chemical powder, water spray, appropriate foam or carbon dioxide. Avoid any contact with substance; wear protective gloves; use safety goggles in combination with breathing protection when working with substance; do not eat, drink or smoke in the workplace.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; OSHA PEL not established; NIOSH REL not established; IDLH not established.

**PERSONAL PROTECTION:** Wear full protective clothing, including rubber boots and heavy rubber gloves; wear chemical safety spectacles, in combination with breathing protection; enclose operations and use local exhaust ventilation at site of chemical release; for extra personal protection, a P3 filter respirator for toxic particles is recommended.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable container, and hold for proper disposal; use wet vacuuming or moisten first to prevent dusting; ventilate area and wash spill site after material pickup is complete.

**HEALTH SYMPTOMS:** Inhalation (cough, sore throat, irritates respiratory tract). (Note: insufficient data are available on the adverse effects of this substance on human health).

**GENERAL COMMENTS:** First aid: flush eyes and skin with large amounts of water for at least fifteen minutes; remove contaminated clothing; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 5; 6; 14; 16.

### **EPICHLOROHYDRIN (C<sub>3</sub>H<sub>5</sub>OCL, 92.525)**

**CAS/DOT #:** 106-98-8/UN2023

**SYNONYMS:** Alpha-epichlorohydrin, chloro-2,3-epoxypropane, glycerol epichlorohydrin, 3-chloro-1,2-propylene oxide, oxirane, chloromethyl.

**PHYSICAL PROPERTIES:** Colorless liquid; irritating chloroform like odor; MP (57°C); BP (117.9°C); SG (1.18); VD (3.2); ST (37 dynes/cm); VP (13 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Incompatible with strong acids, strong bases, strong oxidizing agents; metallic salts; amines; aluminum; chlorine and chlorine compounds and most common metals; will polymerize at temperatures greater than 325°C; FP (-33°C); LFL (3.8%); UFL (21%); AT (779°F).

**EXPOSURE ROUTES:** Ingestion; inhalation; absorption (skin and eyes).

**HUMAN HEALTH RISKS:** Inhalation human TCl<sub>o</sub> 40 ppm; Acute Risks: inflammation of lungs; asthmatic bronchitis; CNS depression; irritation and burning of skin and eyes; headache; nausea; gastrointestinal irritation; unconsciousness; convulsions; Chronic Risks: mutagenic effects; liver and kidney effects.

**HAZARD RISK:** Vapors may flow along surfaces to distant ignition sources and flash back; closed containers exposed to heat may explode; contact with strong oxidizers may cause fire; can produce toxic gases vapors of hydrogen chloride, carbon monoxide, carbon dioxide and phosgene; NFPA code: H 3; F 2; R 2.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; S50; Sfl; Sf2; Sf3; A1.

**MAJOR USES:** Used in the manufacture of epoxy resins, glycerol, pharmaceuticals, agricultural chemicals, coatings, ion exchange resins; glycidyl esters; insecticides; textile chemicals; adhesives; plasticizers; solvent for natural and synthetic resins, gums, cellulose esters and ethers, paints, varnishes and nail enamels and lacquers; stabilizer in chlorine containing materials and an intermediate in the preparation of condensates with polyfunctional substances.

**STORAGE:** Bond and ground containers when transferring liquid; keep container tightly closed; store in a cool, dry, well ventilated, flammable liquid storage area.

**FIRE FIGHTING:** Use water spray; alcohol foam; dry chemical or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (skin); OSHA PEL TWA 5 ppm (19mg/m<sup>3</sup>)(skin); NIOSH REL minimize exposure; IDLH 75 ppm.

**PERSONAL PROTECTION:** wear special protective suit; rubber gloves are recommended; wear chemical safety goggles and face shield; wear appropriate respirators and self-contained breathing apparatus at concentrations above 2 ppm.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; use appropriate foam to blanket release and suppress vapors; clay absorbents are not recommended in cleanup; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (inflammation of the lungs, asthmatic bronchitis); contact (severe irritation or burns); ingestion (nausea, vomiting, headache, convulsions, unconsciousness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 90 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

### 1,2-EPOXYBUTANE (C<sub>4</sub>H<sub>8</sub>O, 72.12)

**CAS/DOT #:** 106-88-7/UN3022

**SYNONYMS:** 1-butene oxide, butylene oxide, ethyl ethylene oxide, 1,2-butene oxide, exthylloxirane.

**PHYSICAL PROPERTIES:** Watery, white liquid; sweet, disagreeable odor; soluble in water; miscible in organic solvents; BP (63°C, 145°F); MP (-130°C, -202°F); SG (0.837); VD (2.2 kg/m<sup>3</sup>); VP (140 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Extremely flammable liquid; may decompose on exposure to moisture; corrosive; LFL (1.7%); UFL (19%); FP (17°F); AT (369°C, 696°F); (-8.3°C, 17°F).

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, nasal passages, throat and lungs; destructive to tissue of the mucous membranes and upper respiratory tract; inflammation and edema of larynx and bronchi; chemical pneumonitis; pulmonary edema; headaches; nausea and vomiting; Chronic Risks: atrophy and necrosis of the spleen and thymus; may alter genetic material; blistering and necrosis.

**HAZARD RISK:** Dangerous fire hazard; incompatible with acids, bases, heat and moisture; combustion emits carbon monoxide and carbon dioxide; NFPA code: H 2; F 3; R 2.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; CAL.

**MAJOR USES:** Used as a component in the manufacture of butylene glycol and its derivatives, butanolamines, surface active gases and gasoline additives; used as a stabilizer in chlorinated hydrocarbon solvents.

**STORAGE:** Keep in a cool place, away from incompatible material; store only if stabilized.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; Short-Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established.

**PERSONAL PROTECTION:** wear full protective clothing and chemical resistant gloves; wear splash-proof safety goggles, in combination with breathing protection; use a closed system of local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment and lighting; for extra personal protection, a filter respirator for organic vapors of low boiling compounds is recommended.

**SPILL CLEAN-UP:** In case of large spills, evacuate danger area; use water spray to cool and disperse vapors; collect leaking liquid in sealable containers or absorb in sand or inert absorbent; flush remaining spill with large amounts of water, but not into confined spaces such as sewers due to possibility of explosion; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (cough, headache, dizziness, labored breathing, confusion, nausea, sore throat, unconsciousness); skin (redness); eyes (pain, redness); ingestion (abdominal pain, nausea, vomiting).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 500 mg/kg; First aid: flush eyes and skin with large amounts of water for at least fifteen minutes; remove contaminated clothing; if inhaled, remove to fresh air and provide artificial respiration if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 4; 5; 10; 14; 16.

## **ETHYL ACRYLATE (C<sub>5</sub>H<sub>8</sub>O<sub>2</sub>, 100.12)**

**CAS/DOT #:** 140-88-5/UN1917

**SYNONYMS:** Acrylic acid ethyl ester, ethoxycarbonethylene, ethyl propenoate, ethyl-2-propenoate, propenoic acid ethyl ester, 2-propenoic acid.

**PHYSICAL PROPERTIES:** Colorless liquid; soluble in alcohol, ether, chloroform and water; MP (-71°C); BP (99.4°C); HV (8.27 kcal/mol); ST (0.025 dyne/cm at 25°C); VP (29.5 mm Hg at 20°C); VD (3.45); SG (0.924).

**CHEMICAL PROPERTIES:** May polymerize on exposure to light; FP (15°C); AT (382°C); LFL (1.8%); UFL (12.1%); HC (655.49 kcal/mol).

**EXPOSURE ROUTES:** Inhalation; ingestion (migrates to food from packing materials); absorption.

**HUMAN HEALTH RISKS:** Acute Risks: shortness of breath; inflammation and edema of larynx and bronchi; nausea; vomiting; headaches; destructive to eyes, skin and upper respira-

tory tract; laryngitis; chemical pneumonitis; pulmonary edema; Chronic Risks: gastrointestinal irritation; coughing; chest pains; lung, liver and kidney damage.

**HAZARD RISK:** Highly flammable; reacts violently with chlorosulfonic acid; reacts vigorously with oxidizing materials; NFPA Code: H 2; F 3; R 2.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2: U113 (U waste); Sf1; Sf2; Sf3; T120; A1.

**MAJOR USES:** Used in the production of fabric finishes, dirt release agents, specialty plastics, latex paints, textiles and paper coatings; monomer in the manufacture of water emulsion paint vehicles; imparts flexibility to hard films.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; STEL 15 ppm; OSHA PEL TWA 25 ppm (100 mg/m<sup>3</sup>)(skin); NIOSH REL potential occupational carcinogen; IDLH 300 ppm.

**PERSONAL PROTECTION:** wear full protective clothing; wear chemical-resistant gloves; wear positive pressure self-contained breathing apparatus; wear splash-proof safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and upper respiratory tract); skin absorption (headache, nausea, vomiting, potential occupational carcinogen).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 760-1020 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 16.

## **ETHYL BENZENE (C<sub>8</sub>H<sub>10</sub>, 106.18)**

**CAS/DOT #:** 100-41-4/UN1175

**SYNONYMS:** Phenylethane, ethylbenzol.

**PHYSICAL PROPERTIES:** Colorless liquid; aromatic odor; soluble in ethyl alcohol, ethyl ether, water, benzene, carbon tetrachloride and sulfur dioxide; BP (136.25°C); MP (-95.01°C); VS (0.64 cP at 25°C); ST (31.5 dynes/cm); DN (0.867 g/mL); VD (3.66).

**CHEMICAL PROPERTIES:** Reacts strongly with oxidizing agents; FP (18°C); LFL (1.0%); UFL (6.7%); HC (9.877 kcal/g); AT (432°C).

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human T<sub>CLo</sub> 100 ppm/8h; Acute Risks: irritation of skin, eyes and upper respiratory tract; vomiting, nausea, headache; dermatitis; narcosis; Chronic Risks: CNS depression; death in high exposures.

**HAZARD RISK:** Incompatible with strong oxidizers; vapors form explosive mixtures with air; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection

**APPLICABLE REGULATIONS:** CA2; S50-b; S62; S10; R2; R3; R5; Sf1; Sf3; CW1; CW2; CW3; CW4; A1.

**MAJOR USES:** Used in the manufacture of styrene, synthetic rubber, automotive and aviation fuels and cellulose acetate; solvent for alkyd surface coatings, propylene oxide, ethyl anthraquinone, ethylbenzene sulfonic acids, alpha methyl benzene alcohol; chemical intermediate for diethylbenzene and acetophenone.

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; STEL 125 ppm; OSHA PEL TWA 100 ppm (435mg/m<sup>3</sup>); STEL 125 ppm; NIOSH REL TWA 100 ppm (435 mg/m<sup>3</sup>); STEL 125 ppm (545 mg/m<sup>3</sup>); IDLH 800 ppm.

**PERSONAL PROTECTION:** wear boots, chemical-resistant gloves, sleeves, aprons, etc.; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; flush remaining ethylbenzene with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); ingestion (headache, dermatitis, narcosis, coma).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 3500 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide respiratory support; if swallowed, get medical attention immediately.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

### **ETHYL CARBAMATE (C<sub>3</sub>H<sub>7</sub>NO<sub>2</sub>, 89.09)**

**CAS/DOT #:** 51-79-6/UN not available

**SYNONYMS:** Carbamic acid ethyl ester, ethylurethane; leucothane; pracarbamine.

**PHYSICAL PROPERTIES:** Colorless crystals or white powder; soluble in water, alcohol, ether, glycerol and chloroform; MP (49°C, 119°F); BP (180°C, 360°F); DN (0.9862 g/ml); VP (10 mm Hg at 10°C); VD (3.07).

**CHEMICAL PROPERTIES:** Reacts strongly with strong acids, strong bases and oxidizing agents; FP (92°C, 197.6°F); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of skin, eyes, mucous membranes and upper respiratory tract; depression; nausea; vomiting; Chronic Risks: damage to immune system, liver, bone marrow and CNS; CNS depression.

**HAZARD RISK:** Explosive when mixed with phosphorous pentachloride; reacts strongly with strong acids, strong bases and oxidizing agents; heating emits toxic fumes of NO<sub>x</sub>; NFPA code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; R4; U238 (U waste); Sfl; A1.

**MAJOR USES:** Intermediate for pharmaceuticals, fungicides, pesticides and organic synthesis; used in biochemical research and medicine; solvent for various organic materials.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; Short-Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus; for extra personal protection, a P3 filter respirator for toxic particles is recommended.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable containers; use wet vacuuming or moisten first to prevent dusting; collect remaining material, then remove to a safe place.

**HEALTH SYMPTOMS:** Inhalation (unconsciousness, irritates eyes, skin and mucous membranes); eyes (redness, pain); ingestion (nausea, vomiting, loss of consciousness, irritates respiratory system).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1809 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 5; 6; 14; 16.

**ETHYL CHLORIDE (C<sub>2</sub>H<sub>5</sub>CL, 64.52)**

**CAS/DOT #: 75-00-3/UN1037**

**SYNONYMS:** Aethylis chloridium, anodynon, chelen, chloroethyl, hydrochloric ether, monochloroethane, muriatic ether, narcotile.

**PHYSICAL PROPERTIES:** Colorless liquid; ether like odor; soluble in water, alcohol and ether; BP (12.5°C); MP (-138.7° C); DN (0.9214 g/ml); VD (2.22); VP (1000 mm Hg at 20° C).

**CHEMICAL PROPERTIES:** Volatile at room temperature; hydrolyzes in the presence of water or alkalis; reacts with strong oxidizing agents and sodium, potassium and their alloys; FP (-50° C); AT (518° C); LFL (3.6%); UFL (14.8%).

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of skin, eyes, mucous membranes and upper respiratory tract; nausea; vomiting; headaches; abdominal cramps; Chronic Risks: kidney and liver damage; cardiac arrhythmias; cardiac arrest.

**HAZARD RISK:** Extremely volatile; severe fire and explosion risk; reacts strongly with oxidizing materials; reacts strongly with water or steam to produce toxic fumes; stable and non-corrosive when dry; NFPA code: H 2; F 4; R 0.

**MEASUREMENT METHODS:** Two charcoal tubes in series; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; R3; Sfl; A1.

**MAJOR USES:** Manufacture of tetraethyl lead and ethylcellulose; solvent for phosphorous, sulfur, resins, oils and waxes; anesthetic; alkylating agent; analytical reagent; organic synthesis; refrigeration.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm; OSHA PEL TWA 1000 ppm (2600 mg/m<sup>3</sup>); NIOSH REL TWA handle with caution in the workplace; IDLH 3800 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, i.e., boots, aprons, chemical-resistant gloves, etc.; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; consult an expert with regard to clean up procedures.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and mucous membranes); skin absorption (cramps, cardiac arrhythmia, cardiac arrest).

**GENERAL COMMENTS:** First aid: wash eyes immediately with large amounts of water; wash skin with large amounts of soap and water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 4; 4; 5; 6; 14; 16.

**ETHYLENE DIBROMIDE (C<sub>2</sub>H<sub>4</sub>BR<sub>2</sub>, 187.88)****CAS/DOT #:** 106-93-4/UN1605**SYNONYMS:** Alpha,beta-dibromoethane, a,a-dibroom, 1,2-dibromoethane, glycol-dibromide, nephis, pestmaster, soilfume, sym-dibromoethane.**PHYSICAL PROPERTIES:** Colorless, heavy liquid; mildly, sweet odor; soluble in water; BP (10.06°C); MP (9.8°C); DN (2.172 g/ml at 25°C); VS (1.727 cP at 20°C); VP (11.7 mm Hg at 25°C).**CHEMICAL PROPERTIES:** Incompatible with alkali metals, oxidizing agents, aluminum and magnesium.**EXPOSURE ROUTES:** Inhalation (ambient air); ingestion (contaminated drinking water); absorption (contact with soil); occupational exposure.**HUMAN HEALTH RISKS:** EPA cancer risk level 5E6 mg/m<sup>3</sup>; Acute Risks: skin blistering; shortness of breath; headaches; nausea; vomiting; gastrointestinal disturbances; wheezing; burning sensation; skin irritation; laryngitis; Chronic Risks: carcinogen; genetic alteration; reproductive disorders; effects on liver, kidneys, lungs and eyes.**HAZARD RISK:** Decomposition emits toxic fumes of Br<sub>2</sub>; incompatible with alkali metals, oxidizing agents, aluminum and magnesium; NFPA code: H 3; F 0; R 0.**MEASUREMENT METHODS:** Charcoal tube; benzene; methanol; gas chromatography with electron capture detection.**APPLICABLE REGULATIONS:** CAA; S1; F3; P waste; Sfl; CW1.**MAJOR USES:** Manufacture of other chemicals, dyes, resins, Gringard reagents, vinyl bromide, pharmaceuticals and ethylene; used as a component in the manufacture of fumigants, gums, waxes, insecticides, nematocides; organic synthesis; scavenger for lead in gasoline; waterproofing; antiknock gasolines.**STORAGE:** Do not use handling equipment or containers composed of magnesium, aluminum or their alloys.**FIRE FIGHTING:** Use dry chemical, carbon dioxide, foam extinguisher or water.**EXPOSURE GUIDELINES:** ACGIH TLV suspected human carcinogen; OSHA PEL TWA 20 ppm; CL 30 ppm; Pk 50 ppm/5M/8H; NIOSH REL TWA 0.045 ppm; IDLH 100ppm.**PERSONAL PROTECTION:** wear protective clothing, chemical-resistant gloves, and chemical safety goggles; wear a face shield and self-contained breathing apparatus.**SPILL CLEAN-UP:** use an appropriate foam to blanket release and suppress vapors; absorb as much as possible in noncombustible materials such as dry earth, sand, or vermiculite; remove all ignition sources.**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (dermatitis, burning sensation, headache, nausea).**GENERAL COMMENTS:** First aid: wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**KEY REFERENCES:** 3; 4; 5; 6; 14; 16.

**ETHYLENE DICHLORIDE (C<sub>2</sub>H<sub>4</sub>CL<sub>2</sub>, 98.96)**

**CAS/DOT #:** 107-06-2/UN1184

**SYNONYMS:** 1,2-dichloroethane, alpha,beta-dichloroethane, ethylene chloride, glyco dichloride,sym-dichloroethane.

**PHYSICAL PROPERTIES:** Clear, oily liquid; pleasant odor and sweet taste; slightly soluble in water; soluble in chloroform and ordinary organic solvents; BP (83°C); MP (-35°C) VP (100 mm Hg at 29.4°C); DN (1.2351 g/ml); VD (3.4).

**CHEMICAL PROPERTIES:** Stable in the presence of alkalis and acids; corrodes iron and other metals at elevated temperatures when in contact with water; FP (15°C); LFL (6.2%) UFL (15.6%); AT (413°C).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin, mucous membrane; and upper respiratory tract; dermatitis; nausea; headaches; vomiting; Chronic Risks: carcinogen may alter genetic material; liver and kidney effects; loss of appetite; low blood sugar levels tremors.

**HAZARD RISK:** Explosive when mixed with nitrogen tetroxide, dimethyl amino propyl amine or liquid ammonia; vigorous reaction when mixed with propylene dichloride, orthodichlorobenzene and aluminum; incompatible with strong oxidizers, strong caustics and active metals such as aluminum, powdered magnesium, sodium or potassium; decomposition emits toxic vapors; dangerous fire hazard if exposed to heat, flame or oxidizers; NFPA code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; S1; D waste; R5; CW1; CW3; CW5; Sfl; A1; A2.

**MAJOR USES:** Used in the manufacture of acetyl cellulose, varnish and finish removers, organic compounds, pharmaceutical products, resins, paints, soaps and scouring compounds, rubber cement, acrylic adhesives, degreasing agents; used in leather cleaning and photography.

**STORAGE:** Keep in a tightly closed container, away from heat, sparks and open flame; store in a cool, dry place.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (40mg/m<sup>3</sup>); OSHA PEL TWA 1 ppm; OSHA PEL STEL 2 ppm; NIOSH REL TWA 1 ppm; NIOSH REL CL 2ppm/15M; IDLH 50 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, chemical-resistant gloves and chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use appropriate foam to blanket release and suppress vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin); skin absorption (headache, nausea, respiratory system).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 670 mg/kg; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide respiratory support if necessary.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 14; 16.

### **ETHYLENE GLYCOL (C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>, 62.08)**

**CAS/DOT #:** 107-21-1/UN not available

**SYNONYMS:** 1,2-dihydroxyethane, 1,2-ethanediol, glycol alcohol, monoethylene glycol, ethylene alcohol, ethylene dihydrate.

**PHYSICAL PROPERTIES:** Clear, colorless, syrupy liquid; slightly viscous; miscible with water, lower aliphatic alcohols, glycerol, acetic acid, acetone and similar ketones, aldehydes and pyridine; MP (-13°C); BP (197.6°C); VP (0.06 mm Hg at 20°C); DN (1.1135 g/ml); OT (3 ppm at 20°C); ST (48.4 dynes/cm at 20°C); VS (21 cP at 20°C).

**CHEMICAL PROPERTIES:** Reacts vigorously with oxidants; AT (398°C); LFL (3.2%); UFL (15.3%); FP (232°F).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, mucous membranes, skin and upper respiratory tract; nervous system disturbances; nausea; headaches; vomiting; Chronic Risks: liver and kidney and CNS damage; reproduction disorders.

**HAZARD RISK:** Moderate explosion hazard when exposed to flame; incompatible with strong oxidizing agents and strong bases; hazardous combustion products are carbon monoxide and carbon dioxide; ignites on contact with chromium trioxide, potassium permanganate and sodium peroxide; NFPA code: H 1; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter; silicon gel; 2-propanol; water; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; Sfl; Sf3; A1.

**MAJOR USES:** Used in the manufacture of organic compounds, cosmetics, lacquers, alkyd resins, paints, coolants and antifreeze, low pressure laminates, break fluids, printing inks, adhesives, wood stains and textiles; leather dyeing; foam stabilizer.

**STORAGE:** Keep in a tightly closed container; store in a cool, dry place.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 50 ppm (127 mg/m<sup>3</sup>); OSHA PEL none; NIOSH REL not established; IDLH not determined.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use non-sparking type tools and equipment; wear self-contained breathing apparatus; for extra personal protection, a P2 filter respirator for organic vapor and harmful dust is recommended.

**SPILL CLEAN-UP:** Ventilate area of leak or spill; collect spilled liquid in sealable containers or absorb with sand or inert material, and place in a chemical waste container; wash away remainder with plenty of water, but not into sewers due to possibility of explosion; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (cough, dizziness, headache, sore throat, nausea, vomiting, drowsiness, pulmonary edema, rapid, involuntary eye movement); skin (dry skin, redness); eyes (pain, eye damage); ingestion (abdominal pain, dullness, nausea, vomiting, headache, lowered blood pressure, stupor, collapse, rapid respiratory and heart rate).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 4700 mg/kg; Personal protection: use self-contained breathing apparatus; wear chemical resistant gloves, safety goggles and protective clothing; First aid: wash eyes and skin immediately with large amounts of water; if inhaled, remove to fresh air and provide respiratory support if necessary; if swallowed, wash mouth with water if person is conscious.

**KEY REFERENCES:** 10; 14; 16.

### **ETHYLENEIMINE (C<sub>2</sub>H<sub>5</sub>N, 43.08)**

**CAS/DOT #:** 151-56-4/UN1185

**SYNONYMS:** aminoethylene, azirane, aziridine, dimethyleneimine, dimethylenimine, ethylenimine.

**PHYSICAL PROPERTIES:** oily, water-white liquid; ammonia-like odor; soluble in ethanol; miscible in water; MP (-72°C, -98°F); BP (57°C, 135°F); DN (0.832 g/cm<sup>3</sup> at 20°C); LSG (0.83); ST (34.5 dynes/cm at 20°C); HV (333 Btu/lb, -8850 cal/g); VD (1.48); VP (160 mmHg at 20°C); OT (1.5 ppm).

**CHEMICAL PROPERTIES:** very corrosive; may polymerize explosively in the presence of acids; polymerization may be caused by elevated temperature, sunlight, oxidizers, or peroxides; uninhibited monomer vapor may form polymer in confined spaces; usually contains inhibitors to prevent polymerization; may react with acids, silver, and chlorinating agents; FP (-11°C, 12°F); LFL/UFL (3.3%, 54.8%); AT (320°C, 608°F); HC (-15,930 Btu/lb, -8850 cal/g); HF (91.9 kJ/mol liquid at 25°C).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin, nose and throat; nausea; vomiting; headache; dizziness; pulmonary edema; liver and kidney damage, Chronic Risks: severe eye burns; skin sensitization; edema of the lungs; mutation of the trachea and bronchi;

secondary bronchial pneumonia; genetic effects; neoplastigenic effects; deep necrosis; carcinogenic.

**HAZARD RISK:** flammable liquid; NFPA rating Health 4, Flammability 3, Reactivity 3; vapors are heavier than air and may travel to an ignition source and flashback; dangerous fire and explosion hazard when exposed to heat, flame or oxidizers; violent reaction with acids, aluminum chloride and substituted anilines, acetic acids, acetic anhydride, acrolein, acrylic acid, allyl chloride, chlorosulfonic acid, epichlorohydrin, hydrogen chloride, hydrogen fluoride, nitric acid, oleum, sulfuric acid, vinyl acetate, carbon disulfide, chlorine, silver, glyoxal, and  $\beta$ -propiolactone; reacts with chlorinating agents to form explosive 1-chloroaziridien; explosive reaction with silver or its alloys to form silver derivatives; violent exothermic reaction in the presence of catalytically active metals or chloride ions; closed containers may rupture violently when heated; combustion by-products include oxides of nitrogen; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**MEASUREMENT METHODS:** not available.

**APPLICABLE REGULATIONS:** CA2; R4; R7; R8; P waste #; (P054); Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; Sf2; Sf3; A1; A4; CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid).

**MAJOR USES:** used in the manufacture of triethylenemelamine, taurine, and fuel oil; used in the manufacturing of adhesives, binders, cosmetics, pharmaceuticals, insect repellants, and ion exchange resins.

**STORAGE:** absorb in dry earth or sand, and place in a sanitary landfill; store in a cool, dry, well-ventilated place; do not use handling equipment or containers composed of magnesium, aluminum or their alloys; store away from heat, sunlight, and oxidizing materials; isolate from strong oxidizers and peroxides.

**FIRE FIGHTING:** Use powder, alcohol-resistant foam, carbon dioxide or water spray; use water spray to cool exposed containers; if possible, allow fire to burn itself out.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (skin); OSHA PEL TWA 1 mg/m<sup>3</sup>(skin); OSHA TLV TWA 0.5 ppm (0.88 mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form non-flammable mixtures; absorb as much as possible in noncombustible materials such as dry earth, and, or vermiculite; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (nausea, vomiting, headache, irritates upper respiratory tract).

**GENERAL COMMENTS:** First aid: wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14.

**ETHYLENE OXIDE (C<sub>2</sub>H<sub>4</sub>O, 44.06)****CAS/DOT #:** 75-21-8/UN1040**SYNONYMS:** Aethylenoxid, dihydrooxirene, dimethylene oxide, 1,2-epoxyethane, oxane.**PHYSICAL PROPERTIES:** Colorless gas; often compressed, liquefied; soluble in water, alcohols and ether; MP (-11.3°C, 11.7°F); BP (10.7°C, 51.3°F); DN (0.8711 g/mL at 20°C); VP (1093 mm Hg at 20°C); VD (1.52); OT (430 ppm).**CHEMICAL PROPERTIES:** Stable; will polymerize; very flammable; reacts violently with acids, alcohols, alkali metals, ammonia, bases, oxidizers, active metals and their salts and water; FP(-4°F); AT (804°F); LFL (3%); UFL (100%).**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.**HUMAN HEALTH RISKS:** Acute Risks: irritation and tissue destruction in skin, eyes, mucous membranes and upper respiratory tract; burning sensation; frostbite; coughing; wheezing; laryngitis; shortness of breath; headache; nausea; vomiting; Chronic Risks: nerve and lung damage; dermatitis; probable carcinogen.**HAZARD RISK:** High fire hazard; decomposes on heating above 500°C; severe explosion hazard when exposed to flame or glycerol; gas/air mixtures explosive; decomposition emits acrid smoke and irritating fumes; gas heavier than air and may travel to ignition source, then flash back; NFPA Code: H 2; F 4; R 3.**MEASUREMENT METHODS:** Petroleum-based charcoal tube; dimethyl formamide; gas chromatograph with electron capture detection.**APPLICABLE REGULATIONS:** CAA; R4; C&Sf; Sf1; Sf2; Sf3; T225-a; A1; A5.**MAJOR USES:** Used in the manufacture of acrylonitrile, nonionic surfactants and organic compounds; fumigant for foodstuffs and textiles; sterilization of surgical instruments; agricultural fungicide.**STORAGE:** Keep in a tightly closed container away from heat, sparks, and open flame in a cool, dry area.**FIRE FIGHTING:** Use powder, alcohol-resistant foam, carbon dioxide or water spray; use water spray to cool exposed containers; if possible, allow fire to burn itself out.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm suspected human carcinogen; OSHA PEL TWA 1 ppm cancer hazard; NIOSH REL TWA < 0.1 ppm (< 0.18 mg/m<sup>3</sup>); NIOSH REL CL 5 ppm/10M/D (9 mg/m<sup>3</sup>); NIOSH PEL < 0.2 mg/m<sup>3</sup>; IDLH 800 ppm.**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; dilution required in enclosed areas such as sewers to eliminate flash potential; remove all ignition sources.**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, mucous membranes, and upper respiratory tract); skin absorption (allergic skin reaction, severe irritation, burning sensation).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 72 mg/kg; First aid: immediately rinse eyes with large amounts of water; remove to fresh air if inhaled; wash out mouth with water if swallowed; provide respiratory support.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14; 16.

### **ETHYLENE THIOUREA (C<sub>3</sub>H<sub>6</sub>N<sub>2</sub>S, 102.17)**

**CAS/DOT #:** 96-45-7/UN not available

**SYNONYMS:** 4,5-Dihydroimidazalene, 1,3-ethylenethiourea, 2-thiol-dihydroglyoxaline.

**PHYSICAL PROPERTIES:** White to pale green crystals, needles or prisms; faint amine odor; soluble in water, methanol, ethanol, ethylene glycol and pyridene; insoluble in acetone, ether, chloroform, benzene and ligroin; MP (197-200°C, 387-392°F).

**CHEMICAL PROPERTIES:** Combustible solid; incompatible with acrolein; decomposes on heating; FP (486°F).

**EXPOSURE ROUTES:** Inhalation (primarily); ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: irritation of skin, eyes, mucous membranes and upper respiratory tract; allergic reactions; Chronic Risks: thyroid, pituitary and liver effects; probable carcinogen.

**HAZARD RISK:** Combustion and decomposition emit toxic fumes of carbon monoxide, carbon dioxide, nitrogen oxides and sulfur oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Particulate filter; water; visible spectrophotometry.

**APPLICABLE REGULATIONS:** CAA; S3; C&Sf; R4; Sf1; Sf2; A1.

**MAJOR USES:** Used in the production of dyes, pharmaceuticals, synthetic resins, insecticides and fungicides; electroplating baths; vulcanization indicator; accelerator for neoprene rubbers.

**STORAGE:** Keep in a tightly closed container in a cool, dry, well-ventilated area.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; OSHA PEL TWA none; NIOSH REL (ETU) use encapsulated form; minimize exposure; potential human carcinogen; IDLH not determined, potential human carcinogen.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** blot spilled powder with a absorbing clay, which may then be removed with a sweeping compound; use a one-to-ten dilution of commercially available 5% hypochlorite solution to mop up contaminated areas.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes, skin and mucous membranes); ingestion (may cause allergic reactions).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1832 mg/kg; First aid: immediately wash eyes with large amounts of water; remove to fresh air if inhaled; wash out mouth with water if swallowed, as long as victim is conscious; provide respiratory support.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 13; 14; 16.

### **ETHYLIDENE DICHLORIDE (C<sub>2</sub>H<sub>4</sub>Cl<sub>2</sub>, 98.97)**

**CAS/DOT #:** 75-34-3/UN2362

**SYNONYMS:** Chlorinated hydrochloric ether, 1,1-dichloroethane, ethylidene chloride.

**PHYSICAL PROPERTIES:** Colorless, oily liquid; ether-like odor; saccharine-like taste; MP(-98°C, -144°F); BP (58°C, 136°F); DN (1.174 g/mL at 17°C); VD (3.4); VP (24 kPa at 20°C); OT (120 ppm).

**CHEMICAL PROPERTIES:** Flammable; reacts violently with oxidizers; volatile; FP (2°F); AT (458°C); LFL (5.6%); UFL (11.4%).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: skin burns; scaliness; rashes; CNS depression; dizziness; drowsiness; dullness; nausea; burning sensations; cardiostimulatory effects; cardiac arrhythmias; unconsciousness; Chronic Risks: body weight depression; skin defatting; liver and kidney damage.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat or flame; moderate explosion hazard when exposed to heat or flame; attacks aluminum, iron and polyethylene; vapor is heavier than air and may travel to ignition source, then flash back; contact with caustics emits flammable and poisonous acetaldehyde gas; decomposition emits irritating and highly toxic fumes of phosgene and hydrogen chloride; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; U076.

**MAJOR USES:** Used in the production of vinyl chloride, 1,1,1-trichloroethane, high vacuum rubber, plastics, oils and fats.

**STORAGE:** Keep in a cool area; do not store in containers composed of magnesium or aluminum or their alloys.

**FIRE FIGHTING:** Use dry chemical, carbon dioxide or foam; use water to keep fire-exposed containers cool.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm; ACGIH STEL 250 ppm; OSHA PEL TWA 100 ppm (400mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (400mg/m<sup>3</sup>); IDLH 3000 ppm.

**PERSONAL PROTECTION:** wear a face shield of at least 8 in. size; wear appropriate NIOSH/MSHA-approved respirator, gloves, safety goggles and other protective clothing; avoid prolonged or repeated exposure; do not allow contact with skin or eyes.

**SPILL CLEAN-UP:** evacuate area; absorb as much as possible with materials such as dry earth, sand, or vermiculite; remove all ignition sources; ventilate area and wash spill site after material pickup.

**HEALTH SYMPTOMS:** inhalation (irritates skin, cardiac effects); contact (skin burns, scaliness, rashes).

**GENERAL COMMENTS:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 13; 14; 16.

## FINE MINERAL FIBERS

**CAS/DOT #:** Not available.

**SYNONYMS:** Not applicable.

**PHYSICAL PROPERTIES:** Fiberglass: white to off-white solid; odorless; LSG (1.96); Mineral Wool, Rockwool Insulation: gray to brown fibers; odorless; MP (982°C, 1800°F); LSG (>1).

**CHEMICAL PROPERTIES:** Polymerization will not occur; stable.

**EXPOSURE ROUTES:** Inhalation (insulation and insulation installment); ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks (Fiberglass): cough; sore throat; asthma; ear, eye and skin infections; headaches; nausea; sinusitis; insomnia; Chronic Risks (Fiberglass): asthma; chemical sensitivities; respiratory disease; Chronic Risks (Erionite): unscheduled DNA synthesis; Chronic Risks (Glasswool): respiratory, lung cancer; Chronic Risks (Rockwool and Slagwool): lung cancer.

**HAZARD RISK:** decomposition of fiberglass emits carbon monoxide, carbon dioxide, hydrocarbons and water; decomposition of rockwool produces dust suppressant oil additive; decomposition of dust suppressant oil additive emits carbon monoxide; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2.

**MAJOR USES:** Fiberglass is used in insulation.

**STORAGE:** store in sealed containers in enclosed area; use suitable, labeled containers; keep closed when not in use; protect from damage.

**FIRE FIGHTING:** Use water, foam, carbon dioxide or dry chemical.

**EXPOSURE GUIDELINES:** ACGIH TLV no information found; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>; 5 mg (respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 3 fibers/cm<sup>3</sup>; (fibers # 3.5 um in diameter and  $\leq$  10 um in length), 5 mg(total dust)/m<sup>3</sup>; IDLH not determined.

**PERSONAL PROTECTION:** Wear clothing suitable for dust protection, including gloves, coveralls, pants, and jacket; wear safety goggles suitable for dust protection; enclose operations and/or use local exhaust ventilation at site of chemical release; wear suitable respiratory protection, including self-contained breathing apparatus; provide safety showers and eye-wash fountains in immediate work area.

**SPILL CLEAN-UP:** Do not dry sweep man-made mineral fibers; wet down with water spray to minimize the amount that becomes airborne; only trained personnel should clean-up; ensure proper ventilation and comply with environmental regulations.

**HEALTH SYMPTOMS:** Inhalation (difficult breathing, headache, dizziness, abrasive action irritates nose and throat); skin (temporary inflammation, skin infections ,increases skin sensitivity); eyes (irritates surface of eyes); ingestion (unlikely to occur).

**GENERAL COMMENTS:** First aid for fiberglass: immediately flush eyes with water; wash skin with water and mild soap, using a washcloth to remove fibers from skin; remove to fresh air if inhaled; do not rub or scratch affected area; First aid for rockwool: wash skin with water and mild soap, using a washcloth to remove fibers from skin; remove to fresh air if inhaled.

**KEY REFERENCES:** 5; 7; 14; 16.

### FORMALDEHYDE (CH<sub>2</sub>O, 30.03)

**CAS/DOT #:** 50-00-0/UN1198

**SYNONYMS:** Formic aldehyde, methanal, methyl aldehyde, methylene oxide, oxomethane.

**PHYSICAL PROPERTIES:** Clear, colorless gas; often used in aqueous solution; pungent odor; MP (-92°C, -144°F); BP (-19.5°C, -3.1°F); LSG (1.083); VD (1.03); VP (52 mm Hg at 37°C); OT (0.5-1.0 ppm).

**CHEMICAL PROPERTIES:** Flammable gas; volatile; corrosive to carbon steel; slowly oxidizes to formic acid; react violently with strong oxidizers; FP (133°F); AT (300°C for gas, 430°C for aqueous solutions); LFL (7.0%); UFL (73%).

**EXPOSURE ROUTES:** Inhalation (contaminated air, indoor air and tobacco smoke); ingestion (contaminated food); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: destructive to tissues of mucous membranes and upper respiratory tract; coughing; wheezing; shortness of breath; chest pain; headache; nausea; vomiting; gastrointestinal effects; skin reactions; Chronic Risks: pulmonary edema; respiratory edema; hemorrhage; coma; alters genetic material.

**HAZARD RISK:** Fire hazard when exposed to heat or flame; moderate explosion hazard; gas more dangerous than vapor under fire conditions; tank rupture produces accumulation of toxic fumes; explosive reaction with nitrogen oxides, performic acid and peroxide; decomposition emits acrid smoke and fumes; NFPA Code: H 3; F 4; R 0.

**MEASUREMENT METHODS:** Particulate filter/impinger; visible spectrophotometry.

**APPLICABLE REGULATIONS:** CAA; CWA; CW1; C&Sf; Sfl; FIFRA; R4.

**MAJOR USES:** Used in the production of dyes, phenolic resins, gelatin, explosives, glass mirrors, artificial silk and albumin; disinfectant; adhesive; waterproofer; preserver; used in dry cleaning industry.

**STORAGE:** Keep in a cool, dry, well-ventilated area; do not store in magnesium or aluminum metal or alloy containers; may require special temperature control.

**FIRE FIGHTING:** Use dry chemical, carbon dioxide or foam; use water to keep fire-exposed containers cool.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm; OSHA PEL TWA 0.75 ppm; OSHA STEL 2 ppm; NIOSH REL TWA 0.016 ppm; IDLH 20 ppm.

**PERSONAL PROTECTION:** wear chemical-resistant gloves and other protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus; avoid prolonged or repeated exposure.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; absorb as much as possible with noncombustible materials such as dry earth, sand or vermiculite; remove all sources of ignition; do not allow contact with skin or eyes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); contact (coughing, wheezing, lacrimation, irritates upper respiratory tract).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 800 mg/kg; First aid: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of water; provide respiratory support.

**KEY REFERENCES:** 3; 4; 6; 11; 14; 16.

**GLYCOL ETHERS (varies by compound; 2-ethoxyethanol: C<sub>4</sub>H<sub>10</sub>O<sub>2</sub>, 90.10; 2-methoxyethanol: C<sub>3</sub>H<sub>8</sub>O<sub>2</sub>, 76.1)**

**CAS/DOT #:** Varies by compound; 2-ethoxyethanol: 110-80-5/UN1171; 2-methoxyethanol: 109-86-4/UN1188

**SYNONYMS:** Cellosolve, ethyl cellosolve, ethylene glycol (mono)ethyl ether, glycol ethyl ether.

**PHYSICAL PROPERTIES:** Colorless liquids; slight odor; 2-ethoxyethanol: soluble in water; BP (135.1°C, 275.2°F); LSG (0.93); VP (5.5 mm Hg at 25°C); VD (3.0); 2-methoxyethanol: soluble in water; MP (-87°C, -125°F); BP (124°C, 255°F); LSG (1.0); VP (9.5 mm Hg at 25°C); VD (2.6).

**CHEMICAL PROPERTIES:** 2-Ethoxyethanol: FP (202°F); AT (455°F); LFL (1.7%); UFL (15.6%); 2-methoxyethanol: may react with strong oxidizers; FP (39°C); LFL (2.3%); UFL (24.5%).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption (cleaning compounds, liquid soaps and cosmetics); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, nose and upper respiratory tract; headache; fatigue; personality change; drowsiness; weakness; shaking; corneal clouding; pulmonary edema; liver damage; kidney damage; conjunctivitis; narcosis; Chronic Risks: fatigue; lethargy; nausea; anorexia; bone marrow depression; encephalopathy; red blood cell depression; tremors; pancytopenia.

**HAZARD RISK:** Flammable and combustible when exposed to heat or flame; 2-ethoxyethanol a moderate explosion hazard in vapor form; 2-ethoxyethanol forms explosive dry mixture with hydrogen peroxide, polyacrylic amide gel and toluene; NFPA Code: 2-ethoxyethanol: H 2; F 2; R 0; 2-methoxyethanol: H 2; F 2; R 0.

**MEASUREMENT METHODS:** 2-Ethoxyethanol: charcoal tube; methylene chloride/methanol; gas chromatography with flame ionization detection; 2-methoxyethanol: charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; S&Sf; Sfl; CAL.

**MAJOR USES:** Used in the production of paints, pastes, gum, perfume, cleaning compounds, liquid soaps, cosmetics and hydraulic fluids; semiconductors; removal of greases, inks, solder paste, flux and oils.

**STORAGE:** Outside or detached storage preferred.

**FIRE FIGHTING:** Use alcohol foam, dry chemical or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (18 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 200 ppm (740 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.5 ppm (1.8 mg/m<sup>3</sup>)(skin); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles or face-shield; above 44°C (111°F), use a closed system of local exhaust ventilation and explosion proof electrical equipment; if the exposure limit is exceeded, wear self-contained breathing apparatus; maintain eye wash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking or spilled liquid in sealable container or absorb with an inert material (e.g., dry earth, sand, vermiculite); wash away remainder with large amounts of water but not into spaces such as sewers because of danger of explosion; use water spray to cool and reduce vapors; and to flush spills away from exposures remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (sore throat, coughing, shortness of breath, headache, drowsiness, nausea, weaknesses, irritates respiratory tract); skin absorption (narcotic effects, drowsiness, weakness, loss of consciousness); skin contact (redness, pain, defatting of skin); eye contact (blurred vision, tearing, stinging, swelling, severe pain); ingestion (abdominal pain, nausea, vomiting, breathing difficulties, liver damage, injury to kidneys, blood changes).

**GENERAL COMMENTS:** First aid: immediately wash eyes and skin with large amounts of water; remove to fresh air; induce vomiting for 2-ethoxyethanol.

**KEY REFERENCES:** 3; 4; 5; 6; 13; 14; 16.

### HEPTACHLOR (C<sub>10</sub>H<sub>5</sub>Cl<sub>7</sub>, 373.32)

**CAS/DOT #:** 76-44-8/UN2761

**SYNONYMS:** Amatin, bunt-no-more, 1,4,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene.

**PHYSICAL PROPERTIES:** Manmade white powder; camphor-like odor; nearly insoluble in water; soluble in organic solvents; MP (95-96°C, 203-205°F); BP (135-145°C, 275-293°F); DN (1.57 g/mL at 20°C); VP (3.0 mm Hg at 25°C); OT (0.02 ppm).

**CHEMICAL PROPERTIES:** Noncombustible; does not ignite readily; stable to light, moisture, and air; FP (not applicable); AT (not applicable); LFL (not applicable); UFL (not applicable).

**EXPOSURE ROUTES:** Inhalation; ingestion; intravenous; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Cancer Risk Level 8E-07 mg/m<sup>3</sup>; Acute Risks: vomiting; convulsions; liver, kidney damage; tremors; respiratory collapse; death; Chronic Risks: personality changes; neurological effects; loss of memory, concentration; liver, kidney damage; blood dyscrasias; potentially mutagenic; has been detected in human milk in areas of high heptachlor concentration.

**HAZARD RISK:** Noncombustible; containers may explode when heated; decomposition emits hydrogen chloride gas, chlorine, carbon monoxide and carbon dioxide; NFPA Code: not available.

**MEASUREMENT METHODS:** Chromosorb tube; toluene; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** Not available.

**MAJOR USES:** Insecticides, pesticides (EPA canceled registration for this use).

**STORAGE:** Keep in a cool, dry area separate from strong bases and food.

**FIRE FIGHTING:** Use dry chemical, carbon dioxide, water spray or foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>(skin); ACGIH TLV STEL 2 mg/m<sup>3</sup>; OSHA PEL TWA 0.5 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup>(skin); IDLH 35mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear dust-proof safety goggles in combination with breathing protection; a system of local exhaust ventilation is preferred to control emissions

at the source and to prevent dispersion into the general work area; use self-contained breathing apparatus in oxygen deficient atmospheres.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; carefully collect remainder, then remove to a safe place; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, tremors, convulsions, blood disorders); skin absorption (feeling of anxiety, irritability, muscle twitching, loss of memory, inability to concentrate); ingestion (liver and kidney damage).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 40-220 mg/kg; First aid: immediately wash eyes with large amounts of water, occasionally lifting lids; if skin contact occurs, immediately remove clothes and wash with large amounts of water and soap; if inhaled, remove to fresh air, apply resuscitation and CPR if necessary; take to medical facility.

**KEY REFERENCES:** 3; 4; 5; 7; 14; 16.

### HEXACHLOROBENZENE (C<sub>6</sub>Cl<sub>6</sub>, 285.2)

**CAS/DOT #:** 118-74-1/UN2729

**SYNONYMS:** Amatin, no bunt, pentachlorophenyl chloroid, perchlorobenzene, sanocid.

**PHYSICAL PROPERTIES:** White needles; insoluble in water; soluble in benzene and boiling alcohol; MP (227-229°C, 441-444°F); BP (323-326°C, 613-619°F); DN (2.044 g/mL at 23°C); VP (0.00001 mm Hg at 20°C); VD (9.8); OT (3.0ppm).

**CHEMICAL PROPERTIES:** Incompatible with strong oxidizers and dimethyl formamide; FP (241°C); AT (596.2°F).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Cancer Risk Level 2E-06 mg/m<sup>3</sup>; EPA RfD 0.0008 mg/kg/d; Acute Risks: irritation of skin, eyes, mucous membranes and upper respiratory tract; photosensitivity resulting in skin lesions when exposed to the sun; drowsiness; incoordination; headache; vomiting; numbness of extremities; Chronic Risks: bullous lesions; effects on lungs, liver and nervous system; cancer.

**HAZARD RISK:** Corrosive; asphyxiating; combustion and decomposition emit toxic fumes of carbon monoxide, carbon dioxide and hydrogen chloride gas; explosion hazard with dimethyl formamide above 65°C; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CWA; CW5; S11; S40-e; CAA; U127; R4; R5; C&Sf; Sfl.

**MAJOR USES:** Used in the production of wood preservatives, rubber and dyes; pesticide; fungicide.

**STORAGE:** Keep in a tightly sealed container in a cool, dry area separated from food.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.025 mg/m<sup>3</sup>; Short Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) NOT ESTABLISHED; IDLH not established.

**PERSONAL PROTECTION:** Wear protective, one-piece, disposable suits that are close-fitting at ankles and wrists; protective gloves, overshoes, and hair covering should always be worn; chemical safety goggles, carefully fitted masks, or respirators are also necessary; for extra personal protection, wear self-contained breathing apparatus and disposable plastic aprons.

**SPILL CLEAN-UP:** Absorb small spills with paper towels, place in hood to evaporate, then burn the towels; material may also be dissolved in a combustible solvent and sprayed into furnace equipped with afterburner and alkali scrubber.

**HEALTH SYMPTOMS:** Inhalation (headache, drowsiness, irritates eyes, skin and mucous membranes); skin (lesions of the skin); eyes (irritates eye membranes); ingestion (headache, vomiting, convulsions, in coordination, loss of consciousness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 10g/ kg; First aid: immediately wash eyes with large amounts of water for 15 minutes following exposure; if skin contact occurs, immediately remove clothing and wash skin with large amounts of water; if inhaled, remove to fresh air and supply oxygen or resuscitate if needed.

**KEY REFERENCES:** 3; 6; 7; 11; 14; 16.

## HEXACHLOROBUTADIENE (C<sub>4</sub>Cl<sub>6</sub>, 260.76)

CAS/DOT #: 87-68-3/UN2279

**SYNONYMS:** HCBd, hexachloro-1,3-butadiene, perchlorobutadiene.

**PHYSICAL PROPERTIES:** Slightly yellow to colorless, clear liquid; faint turpentine odor; insoluble in water; soluble in alcohol and ether; MP (-21°C, -6°F); BP (210°C, 410°F); LSG (1.665); VS (2.47 cP at 37.7°C); VP (0.3 mm Hg at 77°C); OT (1.0 ppm).

**CHEMICAL PROPERTIES:** Combustible; incompatible with strong oxidizers; compatible with numerous resins; FP (not available); AT (1130°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion (least likely); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Cancer Risk Level 5E-05 mg/m<sup>3</sup>; Acute Risks: irritation of skin and eyes; burning; coughing; wheezing; laryngitis; shortness of breath; headache; nausea; vomiting; kidney damage; respiratory spasm; death; Chronic Risks: damage to developing fetus; cancer of liver and kidneys.

**HAZARD RISK:** Flammable; explosion risk; gas heavier than air; formation of toxic vapors under fire conditions; formation of corrosive vapors; NFPA Code: H 2; F 1; R 1.

**MEASUREMENT METHODS:** XAD tube; hexane; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CWA; CW1; CW5; CAA; S3; R4; U128; R5; C&Sf; Sfl; A1.

**MAJOR USES:** Used in the production of lubricants and synthetic rubber; solvent; pesticide; heat transfer fluid; hydraulic fluid; isolating agent for transformers.

**STORAGE:** Keep in a tightly closed container in a cool, well-ventilated area.

**FIRE FIGHTING:** Use dry chemical, carbon dioxide, water spray or alcohol foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.24 mg/m<sup>3</sup>; OSHA PEL TWA none; NIOSH REL TWA 0.02 ppm (0.24 mg/m<sup>3</sup>) (skin), carcinogen; IDLH not determined, carcinogen.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, solvent-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; wear positive pressure self-contained breathing apparatus; vent workplace; wash thoroughly after each exposure.

**SPILL CLEAN-UP:** Ventilate area of spill or leak; absorb small quantities on paper towels and cautiously evaporate in a fume hood; absorb large quantities in sand or inert absorbent for proper disposal in a high-temperature incinerator equipped with hydrochloric acid scrubber; remove all ignition sources.

**HEALTH SYMPTOMS:** Inhalation (irritates mucous membranes, respiratory difficulty, headache, nausea, vomiting); eyes/skin (may cause burns and irritation); ingestion (nausea, vomiting, convulsions, unconsciousness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 82 mg/kg; First aid: immediately wash eyes with large amounts of water for 15 minutes following exposure, separating eyelids; if skin contact occurs, immediately remove clothes and wash with water and soap; if inhaled, remove to fresh air and apply resuscitation and CPR as needed; in all cases, immediately seek medical attention.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14; 16.

### HEXACHLOROCYCLOPENTADIENE (C<sub>5</sub>Cl<sub>6</sub>, 272.29)

**CAS/DOT #:** 77-47-4/UN2646

**SYNONYMS:** HCCPD, hexachloro-1,3-cyclopentadiene, perchlorocyclopentadiene.

**PHYSICAL PROPERTIES:** Light yellow to amber liquid; pungent, unpleasant odor; soluble in water; MP (-10°C, 14°F); BP (239°C, 462°F); DN (1.717 g/mL at 15°C); VD (9.42); VP (0.13 psi at 20°C).

**CHEMICAL PROPERTIES:** Noncombustible liquid; incompatible with strong oxidizers; decomposes when exposed to moist air or water; reacts with water to form hydrochloric acid; corrodes most metals in presence of moisture; FP (not applicable); AT (not applicable); LFL (not applicable); UFL (not applicable).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes and mucous membranes; burning sensation; destructive to mucous membranes in upper respiratory tract; inflammation and edema of the bronchi; larynx spasm and inflammation; pulmonary edema; coughing; wheezing; laryngitis; shortness of breath; headache; nausea; vomiting; death; Chronic Risks: liver damage; damage to kidneys; lung tissue degeneration.

**HAZARD RISK:** Corrosive; decomposition emits toxic fumes of carbon monoxide, carbon dioxide and hydrogen chloride gas; accumulation of explosive hydrogen gas in closed areas in the presence of moisture; NFPA Code: not available.

**MEASUREMENT METHODS:** Porapak tube; hexane; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CWA; CW5; S11; S50-a; CAA; R4; R5; U130; C&SF; Sfl; A1.

**MAJOR USES:** Used in the production of dyes, pesticides (heptachlor, aldrin, endrin), fungicides, pharmaceuticals and flame retardant materials.

**STORAGE:** Keep in a tightly sealed container in a cool, dry area; keep away from moisture.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.11 mg/cm<sup>3</sup>; OSHA PEL none; NIOSH REL TWA 0.01 ppm (0.1 mg/m<sup>3</sup>); IDLH not determined.

**PERSONAL PROTECTION:** wear NIOSH/MSHA-approved breathing apparatus, chemical-resistant gloves, a face shield and other protective clothing; avoid prolonged exposure; wash thoroughly after each exposure; provide local exhaust ventilation to keep exposure levels below Threshold Limit Value (TLV); maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Ventilate area of spill or leak; take up spill with absorbent material, such as dry earth, sand or vermiculite; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (headache, coughing, wheezing, irritates eyes, skin and mucous membranes); skin (burning sensation, possible blistering); eyes (irritation, redness, pain); ingestion (nausea, vomiting, shortness of breath, chemical pneumonitis).

**GENERAL COMMENTS:** First aid: immediately wash eyes with water for 15 minutes following exposure, occasionally separating eyelids; if skin contact occurs, immediately remove clothing and wash with water for 15 minutes; if inhaled, remove to fresh air and give resuscitation as needed.

**KEY REFERENCES:** 4; 5; 6; 7; 12; 14; 16.

## **HEXACHLOROETHANE (C<sub>2</sub>Cl<sub>6</sub>, 236.72)**

**CAS/DOT #:** 67-72-1/UN9037

**SYNONYMS:** Carbon hexachloride, ethane hexachloride, perchloroethane.

**PHYSICAL PROPERTIES:** White crystalline powder; camphor-like odor; insoluble in water; soluble in alcohol, ether, hot fluoric acid, benzene and chloroform; MP (186°C, 367°F); BP (sublimes at 185°C, 365°F); DN (2.091 g/mL at 20°C); VP (1 mm Hg at 33°C); VD (8.16).

**CHEMICAL PROPERTIES:** Nonflammable; reacts with alkalis, metals such as zinc, cadmium, aluminum, hot iron and mercury; with water promotes corrosion of metals; FP (not applicable); AT (not applicable); LFL (not applicable); UFL (not applicable).

**EXPOSURE ROUTES:** Inhalation (contaminated air); ingestion (contaminated drinking water); absorption (skin and eye contact); occupational exposure.

**HUMAN HEALTH RISKS:** Rfd 0.01 mg/kg/d; EPA Group C possible human carcinogen of low carcinogenic hazard; Acute Risks: irritation of eyes, skin, mucous membranes and upper respiratory tract; dizziness; sleepiness; coughing; pain; redness; vomiting; diarrhea; narcosis; CNS depression; stupefying; Chronic Risks: dermatitis; blepharospasm; photophobia; lacrimation; liver damage; tremors; ataxia.

**HAZARD RISK:** Combustion emits toxic vapors of phosgene and hydrogen chloride; slightly explosive through spontaneous chemical reaction; NFPA Code: not available.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S3; R3; R4; R5; R7; R8; C&Sf; Sf1; Sf3; CWA; CW4; CW5; A1.

**MAJOR USES:** Used in the production of nitrocellulose, pyrotechnics and smoke devices, pharmaceuticals, moth repellents, alloys, lube oils and explosives; solvent; insecticide; veterinary antihelmintic to destroy tapeworms; retarding agent in fermentation.

**STORAGE:** Keep in a tightly closed container in a cool, dry area.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm (9.7 mg/m<sup>3</sup>); OSHA PEL TWA 1 ppm (10 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 1 ppm (10mg/m<sup>3</sup>)(chloroethane) reduce to lowest level; IDLH 300 ppm.

**PERSONAL PROTECTION:** wear NIOSH/MSHA-approved respirator, chemical-resistant gloves and other protective clothing; use only in chemical fume hood; avoid prolonged or repeated exposure; wash thoroughly after each exposure; use dust-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spill substance into sealable containers; if appropriate, moisten first to avoid raising dust; carefully collect remainder, then remove to a safe place; wash spill site after material pickup is complete.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, sore throat, coughing, irritates eyes, skin and upper respiratory tract); skin absorption (tremors, ataxia, sleepiness, stupor, narcosis); contact (lacrimation, redness, pain, dermatitis); ingestion (abdominal pain, nausea, vomiting, diarrhea, damage to liver and kidneys).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 4460 mg/kg; First aid: wash eyes or skin with large amounts of water for 15 minutes following exposure; immediately remove clothing; wash out mouth with water if swallowed, as long as victim is conscious.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 16.

### **HEXAMETHYLENE-1,6-DIISOCYANATE (C<sub>8</sub>H<sub>12</sub>N<sub>2</sub>O<sub>2</sub>, 168.22)**

**CAS/DOT #:** 822-06-0/UN2281

**SYNONYMS:** 1,6-Diisocyanatohexane, HDI, hexamethylene-1,6-diisocyanate.

**PHYSICAL PROPERTIES:** Clear, colorless to pale yellow liquid; sharp, pungent odor; slightly soluble in water; MP (25°C, 77°F); BP (255°C, 491°F); DN (1.053 g/mL at 20°C); VP (0.05 mm Hg at 25°C); OT (0.001 ppm).

**CHEMICAL PROPERTIES:** Combustible liquid; polymerizes above 392°F; reacts vigorously with water, strong acids, strong bases, amines, carboxylic acids and organotin, heat, strong oxidizers; FP (140°C); AT (454°F); LFL (0.9%); UFL (9.5%).

**EXPOSURE ROUTES:** Inhalation (emissions from combustion); ingestion; absorption; occupational exposure (polyurethane industry).

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, nose and throat; cough; wheezing; asthma; skin blisters; corneal damage; pulmonary edema; shortness of breath; Chronic Risks: lung damage; depressed weight gain; skin sensitization; effects on eyes, skin and respiratory organs.

**HAZARD RISK:** Fire hazard; combustion produces toxic and corrosives fumes of nitrogen oxides and hydrogen cyanide; decomposition with water emits amine and polyureas; NFPA Code: not available.

**MEASUREMENT METHODS:** Impinger; reagent; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** CAA; CA1; C&Sf; Sf1; Sf3.

**MAJOR USES:** Used in the production of polyurethane, dental materials, contact lenses and medical absorbents.

**STORAGE:** Keep in a tightly closed container in a cool, dry place; keep away from moisture; store in the dark.

**FIRE FIGHTING:** Use dry chemical powder or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.005 ppm (0.035 mg/m<sup>3</sup>); OSHA PEL none; NIOSH REL TWA 0.005 ppm (35 mg/m<sup>3</sup>); NIOSH REL CL 0.020 ppm (140 mg/m<sup>3</sup>); IDLH not determined.

**PERSONAL PROTECTION:** Wear complete protective clothing, including chemical-resistant gloves; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** Evacuate danger area and consult an expert; ventilate area of spill or leak; collect leaking and spilled liquid in sealable containers, or absorb in sand or inert absorbent and remove to safe place.

**HEALTH SYMPTOMS:** Inhalation (cough, sore throat, burning sensation, ;absorb breathing, shortness of breath); skin (redness, skin burns, blisters); eyes (pain, redness, swelling of eyelids); ingestion (coughing, wheezing)

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 710 L/kg; First aid: immediately wash eyes with large amounts of water; immediately wash skin with water and soap; provide respiratory support.

**KEY REFERENCES:** 4; 5; 6; 11; 14; 16.

### HEXAMETHYLPHOSPHORAMIDE (C<sub>6</sub>H<sub>18</sub>N<sub>3</sub>OP, 179.24)

**CAS/DOT #:** 680-31-9/UN not available

**SYNONYMS:** Hexamethylphosphoramidate, phosphoric acid hexamethyltriamide, tris(dimethylamino)phosphine oxide.

**PHYSICAL PROPERTIES:** White to colorless liquid; mobile; mild amine odor; soluble in water and in many polar and nonpolar solvents; MP (7°C, 45°F); BP (230°C, 446°F); VP (0.07 mm Hg at 25°C); DN (1.024 g/mL at 25°C); VD (6.18).

**CHEMICAL PROPERTIES:** Combustible; decomposes on heating; FP (222°F); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin, mucous membranes and upper respiratory tract; burning in the throat; labored breathing; shortness of breath; abdominal pain; CNS depression; Chronic Risks: abdominal pain; bronchopneumonia; may alter genetic material; CNS and gastrointestinal effects; kidney and lung damage; effects on bone marrow; may cause cancer.

**HAZARD RISK:** Fire hazard; explosion risk when temperature exceeds flash point; decomposition upon heating or burning emits toxic fumes of phosphorus oxides and nitrogen oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf3; T225-975.

**MAJOR USES:** Used in the production of aramid polyamide fibers, kevlar fabrics and functional fluids; UV inhibitor; chemosterilant for insects; solvent; polymerization catalyst and stabilizer; flame retardant; promotes stereospecific reactions.

**STORAGE:** Keep in a tightly closed container in a cool, dry, well-ventilated area.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV suspected human carcinogen; OSHA PEL none; NIOSH REL potential occupational carcinogen; IDLH not determined, carcinogen.

**PERSONAL PROTECTION:** Wear rubber boots, heavy rubber gloves, and disposable coveralls; wear chemical safety goggles or face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus; wash thoroughly after each exposure.

**SPILL CLEAN-UP:** Collect leaking and spilled liquid in sealable containers, or absorb in sand or inert absorbent and hold for waste disposal; ventilate area and wash spill site after material pickup is completed.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes, skin, and respiratory system); ingestion (burning sensation, abdominal pain, difficult breathing, other gastrointestinal effects).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2650 mg/kg; First aid: immediately rinse eyes with large amounts of water for 15 minutes following exposure; if skin contact occurs, immediately remove clothing and wash with large amounts of water; if inhaled, remove to fresh air, and give resuscitation if needed; wash out mouth with water if swallowed, as long as victim is conscious.

**KEY REFERENCES:** 4; 5; 6; 7; 14; 16.

### **HEXANE (C<sub>6</sub>H<sub>14</sub>, 86.20)**

**CAS/DOT #:** 110-54-3/UN1208

**SYNONYMS:** n-Hexane, hexyl hydride.

**PHYSICAL PROPERTIES:** Colorless, clear liquid; faint odor; insoluble in water; miscible in chloroform, ether and alcohol; MP (-95.6°C, -140.1°F); BP (69°C, 156°F); DN (0.655 g/mL at 25°C); VP (150 mm Hg at 25°C); VD (2.97); OT (130 ppm).

**CHEMICAL PROPERTIES:** Highly flammable; reacts vigorously with oxidizers; FP (-9.4°F); AT (437°F); LFL (1.2%); UFL (7.5%).

**EXPOSURE ROUTES:** Inhalation (widely occurring atmospheric pollutant); ingestion; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group D not classifiable as to human carcinogenicity; Acute Risks: irritation of eyes, throat and mucous membranes; effects on peripheral nervous system; CNS depression; dizziness; light-headedness; numbness of extremities; dermatitis; headache; nausea; muscle weakness; chemical pneumonia; Chronic Risks: polyneuropathy; muscle weakness; blurred vision; numbness in extremities; fatigue; headache; effects on eyes, skin, respiratory system and CNS.

**HAZARD RISK:** Very dangerous fire and explosion hazard when exposed to heat or flame; mixtures with dinitrogen tetraoxide may explode at 28°C; formation of toxic vapors; NFPA Code: H 1; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** C&Sf; Sf3; T799B.

**MAJOR USES:** Used as a solvent in glues, varnishes, cements and inks; used in the industries of dry cleaners, pesticides, thermometers, fuel, alcohol, pharmaceuticals; determination of refractive index of minerals.

**STORAGE:** Keep under conditions necessary for flammable substances.

**FIRE FIGHTING:** Use carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (180 mg/m<sup>3</sup>); OSHA PEL TWA 500 ppm (1800 mg/m<sup>3</sup>); NIOSH REL TWA (alkanes) 350 mg/m<sup>3</sup>; IDLH 1100 ppm.

**PERSONAL PROTECTION:** wear a gas-tight, fireproof suit; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** collect leaking and spilled liquid in sealable containers or absorb with inert materials (e.g., dry earth, sand, or vermiculite); wash remaining material with large amounts of water but not into spaces such as sewers because of danger of explosion.

**HEALTH SYMPTOMS:** inhalation (vertigo, drowsiness, fatigue, loss of appetite, anorexia); ingestion (nausea, vomiting, diarrhea, abdominal pain, labored breath).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 28710 mg/kg; First aid: immediately wash eyes with large amounts of water; immediately wash skin with water and soap; remove to fresh air and provide respiratory apparatus if necessary; drink water or milk if ingested.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 13; 14; 16.

## HYDRAZINE (H<sub>4</sub>N<sub>2</sub>, 32.06)

**CAS/DOT #:** 302-01-2/UN2029

**SYNONYMS:** Diamide, diamine, hydrazine (anhydrous), hydrazine base.

**PHYSICAL PROPERTIES:** Clear, colorless, fuming, oily liquid; ammonia-like odor; highly soluble in water; insoluble in chloroform and ether; MP (2.0°C, 36°F); BP (113.5°C, 236.3°F); VP (14.4 mm Hg at 25°C); DN (1.004 g/mL at 25°C); ST (66.45 dynes/cm at 25°C); VS (0.913cP at 25°C); OT (3.7 ppm).

**CHEMICAL PROPERTIES:** Combustible and flammable; thermally unstable; oxygen not required for decomposition; incompatible with oxidizers, hydrogen peroxide, nitric acid, metallic oxides and acids; FP (99°F); ignition temperatures vary widely in contact with iron, iron rust, stainless steel and glass; AT (not available); LFL (2.9%); UFL (98%).

**EXPOSURE ROUTES:** Inhalation (contaminated air and tobacco smoke); ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: itching; swelling; blistering; temporary blindness; eye and skin burns; dermatitis; pulmonary edema; dizziness; nausea; seizures; Chronic Risks: damage to liver and lungs, CNS; coma; may cause cancer.

**HAZARD RISK:** Fire hazard; decomposes at room temperature; ignites spontaneously with oxidizers or porous materials such as earth, wood or cloth; decomposition promoted by monel, bronze, brass, cadmium, gold, molybdenum and stainless steel; NFPA Code H 3; F 3; R 3.

**MEASUREMENT METHODS:** Bubbler; reagent; visible spectrophotometry.

**APPLICABLE REGULATIONS:** CAA; CA2; R4; R7; R8; C&Sf; Sf1; Sf2; Sf3; A1; A5.

**MAJOR USES:** Used in the production of pesticides, pharmaceuticals, explosives, polymers, antioxidants, metal reductants, photography chemicals, textile dyes and fuels; water treatment for corrosion protection; electrolytic plating.

**STORAGE:** Keep in a tightly closed container in a cool, dry area away from open flame and heat; detached storage preferred.

**FIRE FIGHTING:** Use water spray, carbon dioxide or dry chemical powder; fight fire from maximum possible distance; may require flooding to prevent reignition.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (skin); OSHA PEL TWA 1 ppm (1.3mg/m<sup>3</sup>)(skin); NIOSH REL CL 0.04 mg/m<sup>3</sup>/2H; IDLH 50 ppm.

**PERSONAL PROTECTION:** wear NIOSH/MSHA-approved respirator, face shield of at least 8 in. size, safety goggles, chemical-resistant gloves and other protective clothing

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; use activated carbon and copper ion catalysts to remove hydrazine from wastewater; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose, itching, swelling, blistering of eyelids, temporary blindness); ingestion or absorption (nausea, dizziness, headache); contact (caustic-like burns).

**GENERAL COMMENTS:** First aid: immediately wash eyes or skin with large amounts of water; if inhaled remove to fresh air; if ingested, do not induce vomiting - give egg whites; call a physician immediately.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 16.

### HYDROCHLORIC ACID (HCl, 36.5)

**CAS/DOT #:** 7647-01-0/UN1050 (anhydrous), UN2186 (solution)

**SYNONYMS:** Anhydrous hydrogen chloride, aqueous hydrogen chloride, spirits of salt.

**PHYSICAL PROPERTIES:** Clear, colorless to light yellow liquid; pungent, irritating odor; soluble in water, alcohol and benzene; MP (-114.2°C, -173.6°F); BP (-85°C, -121.0°F); VP (3.23 psi at 21.1°C); ST (23 dynes/cm at 118.16K); DN (0.630g/m<sup>3</sup> at 319.15K); VS (0.405cP at 118.16K).

**CHEMICAL PROPERTIES:** Noncombustible; strong acid in water; reacts vigorously with alkalis and with many organic materials; usually fuming; attacks metals; corrosive; FP (not applicable); AT (not applicable); LFL (not applicable); UFL (not applicable).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human LC<sub>50</sub> 1300 ppm for 30 minutes; RfC 0.007 mg/m<sup>3</sup>; Acute Risks: burning sensation; hoarseness; coughing; wheezing; shortness of breath; headache; nausea; vomiting; dental discoloration and erosion; inflammation and ulceration of the respiratory tract; Chronic Risks: vision damage; gastritis; dermatitis; burns; destructive to tissues; spasms; pneumonitis; pulmonary edema.

**HAZARD RISK:** Ignites on contact with fluorine, hexalithium disilicide, metal acetylides and carbides; decomposition emits toxic vapors of chlorine gas; attacks many metals to form toxic fumes; NFPA Code: H 3; F 0; R 1.

**MEASUREMENT METHODS:** Silica gel; sodium bicarbonate/sodium carbonate; ion chromatography.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; CWA; CW1; CW2; FIFRA; A1; A5.

**MAJOR USES:** Component in food processing; used in environmental applications for pH control, neutralization of waste streams, treatment and general cleaning; used in industries of electroplating, leather tanning, steel pickling and photography; antiseptic; toilet bowl cleaner.

**STORAGE:** Keep in a tightly closed container in a cool, dry, well-ventilated area; separate from bases, strong reducers, oxidizers and metals.

**FIRE FIGHTING:** Use water; neutralize with chemically basic substances such as soda ash or slaked lime; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 5 ppm; OSHA PEL CL 5 ppm (7 mg/m<sup>3</sup>); NIOSH REL CL 5 ppm (7mg/m<sup>3</sup>); IDLH 50 ppm.

**PERSONAL PROTECTION:** wear NIOSH/MSHA-approved respirator, rubber gloves, safety goggles, face shield of at least 8 in. size and other protective clothing; use only with mechanical exhaust; wash thoroughly after each exposure

**SPILL CLEAN-UP:** use water fog or spray to knock down and absorb vapors; control runoff and properly dispose of discharge material.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose throat, and larynx); contact (liquid frostbite).

**GENERAL COMMENTS:** First aid: immediately wash eyes with large amounts of water for 15 minutes following exposure; immediately remove clothing and wash skin with water; if inhaled, remove to fresh air; if ingested, wash mouth out with water and do not induce vomiting - give milk; call physician immediately.

**KEY REFERENCES:** 4; 5; 6; 7; 10; 11; 12; 13; 14; 16.

**HYDROGEN FLUORIDE (HF, 20.01)**

**CAS/DOT #:** 7664-39-3/UN1052(anhydrous), UN1790(solution)

**SYNONYMS:** Anhydrous hydrogen fluoride, aqueous hydrogen fluoride, hydrofluoric acid.

**PHYSICAL PROPERTIES:** Clear, colorless gas or fuming liquid; irritating odor; highly soluble in water and alcohol; slightly soluble in ether; MP (-83.1°C, -117.6°F); BP (19.54°C, 67.2°F); DN (0.699 m/L at 22°C); VP (400 mm Hg at 2.5°C); OT (0.042 ppm).

**CHEMICAL PROPERTIES:** Nonflammable; corrosive to metals; attacks glass and concrete; strong reactions with metals, water and steam; FP (not applicable); AT (not applicable); LFL (not applicable); UFL (not applicable).

**EXPOSURE ROUTES:** Inhalation (industrial emissions, coal combustion, volcanoes and tobacco smoke); ingestion (drinking water dosed with fluoride and contaminated food); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human LCLo 50 ppm for 30 minutes; Acute Risks: extremely destructive to tissues of the mucous membranes, upper respiratory tract, eyes and skin; burning sensation; coughing; wheezing; bronchitis; bone changes; laryngitis; shortness of breath; headache; nausea; vomiting; Chronic Risks: fluorosis; effects on liver, kidney, eyes, bones, skin and respiratory system.

**HAZARD RISK:** Not combustible, but extremely irritating if involved in fire; evolves heat when combined with water; corrosive; forms hydrogen gas upon contact with metals; heating emits highly corrosive fumes; NFPA Code: not available.

**MEASUREMENT METHODS:** Silica gel; sodium bicarbonate/sodium carbonate; ion chromatography.

**APPLICABLE REGULATIONS:** CAA; R4; U134; C&Sf; Sf1; Sf2; Sf3; A2; A5.

**MAJOR USES:** Used in the production of plastics, separated uranium isotopes, frosting, etched glass, dyes and electrical bulbs; active constituent in drinking water.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from strong bases, silica, incompatible metals, concrete, glass and ceramics; do not store in glass.

**FIRE FIGHTING:** Do not use hydrous agents; use water spray to cool exposed containers but do not allow direct contact.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 3ppm; OSHA PEL TWA 3 ppm; OSHA PEL STEL 6 ppm; NIOSH REL TWA 3 ppm (2.5 mg/m<sup>3</sup>); NIOSH REL CL 6 ppm (5 mg/m<sup>3</sup>); IDLH 30 ppm.

**PERSONAL PROTECTION:** wear long rubber aprons, long rubber gauntlets, high rubber boots, and wide plastic face shield; wear plastic lensed eye goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray or fog to knock down and absorb vapors; if in liquid form, absorb in noncombustible material or allow to vaporize, and disperse the gas.

**HEALTH SYMPTOMS:** inhalation (pulmonary edema, severe eye and skin burns); contact (pain, visible damage).

**GENERAL COMMENTS:** First aid: irrigate eyes and seek medical attention; if skin contact occurs immediately flush with water; if inhaled provide respiratory support; if ingested seek medical attention immediately.

**KEY REFERENCES:** 3; 4; 5; 6; 11; 14; 16.

### HYDROQUINONE (C<sub>6</sub>H<sub>6</sub>O<sub>2</sub>, 110.12)

**CAS/DOT #:** 123-31-9/UN2662

**SYNONYMS:** p-Benzenediol, 1,4-benzenediol, dihydroxybenzene, hydroquinol, quinol.

**PHYSICAL PROPERTIES:** Colorless, light tan or light gray crystals and prisms; insoluble in water; MP (170°C, 338°F); BP (285°C, 545°F); DN (1.358 g/L at 20°C); VD (3.81); VP (4 mm Hg at 150°C).

**CHEMICAL PROPERTIES:** Combustible; rapid oxidation in presence of alkalis and light; reacts with sodium hydroxide, alkalis and oxidizers; AT (960°F); FP (329°F); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (tobacco smoke and diesel exhaust); ingestion (contaminated food); absorption (black and white film development); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of mucous membranes, upper respiratory tract, eyes and skin; may cause allergic reaction; burns; colored urine; muscle twitch; CNS excitement; suffocation; delirium; increased pulse rate without fall in blood pressure; respiratory failure; Chronic Risks: dermatitis; anemia; skin depigmentation; effects on kidney and eyes; corneal and conjunctival discoloration; cancer.

**HAZARD RISK:** Fire hazard when exposed to heat or flame; dust cloud may explode in enclosed area if ignited; explosive reaction with oxygen; violent explosion with sodium hydroxide; strong oxidizing agent; NFPA Code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter; acetic acid; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** CAA; T120-a; T799-18; C&Sf; Sf2; Sf3; A1.

**MAJOR USES:** Used in the production of foods, rubber, dyes, paints, varnishes, acrylic monomers, motor fuels, oils and pharmaceuticals; photography development; polymerization inhibitor.

**STORAGE:** Keep in a tightly closed container in a cool, dry area; store under nitrogen; keep away from strong bases and food.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 mg/m<sup>3</sup>; OSHA PEL TWA 2mg/m<sup>3</sup>; NIOSH REL CL 2mg/m<sup>3</sup>/15M; IDLH 50mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear NIOSH/MSHA-approved respirator, chemical-resistant gloves, safety goggles and protective clothing; do not wear contact lenses; use only in chemical fume hood

**SPILL CLEAN-UP:** sweep up material, place in a suitable container, and hold for waste disposal; evacuate area and avoid dust clouds; flush with large amounts of water and disperse, but not into water intakes of confined spaces such as sewers; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, breathing difficulty); ingestion (ringing in the ears, nausea, vomiting, dizziness, suffocation); contact (dermatitis, ulceration of the cornea).

**GENERAL COMMENTS:** First aid: irrigate eyes and seek medical attention; if skin contact occurs wash with water and soap immediately; if inhaled provide respiratory support; if ingested seek medical attention immediately.

**KEY REFERENCES:** 3; 4; 6; 11; 14; 16.

### ISOPHORONE (C<sub>9</sub>H<sub>14</sub>O, 138.2)

**CAS/DOT #:** 8-59-1/UN1993

**SYNONYMS:** Isoacetophorone, 3,5,5-trimethyl-2-cyclohexenone.

**PHYSICAL PROPERTIES:** Colorless to white liquid; characteristic, peppermint or camphor-like odor; insoluble in water; soluble in vinyl resins, cellulose ester, ether, acetone and alcohols; MP (-8°C, 18°F); BP (215°C, 419°F); LSG (0.92°C); VP (0.2 mm Hg at 20°F); VS (2.62cP at 20°C); OT (0.2 ppm).

**CHEMICAL PROPERTIES:** Combustible; reacts with oxidizers, strong alkalis and amines; FP (184°C); AT (864°F); LFL (0.8%); UFL (3.8%).

**EXPOSURE ROUTES:** Inhalation (ink, paints and adhesives); ingestion (contaminated drinking water); absorption; occupational exposure (printing and coal-fired power plants).

**HUMAN HEALTH RISKS:** Eye human 25 ppm for 15 minutes; Acute Risks: severe irritation of skin, eyes, mucous membranes and upper respiratory tract; blurred vision; redness; dry skin; tightness in chest; sore throat; asthma; difficulty breathing; cough; bronchitis; abdominal pain; malaise; narcosis; nausea; headache; dizziness; fatigue; Chronic Risks: dermatitis; CNS depression; effects on lungs, kidney, eyes, skin and CNS; cancer.

**HAZARD RISK:** Fire hazard; flammable and explosive when exposed to heat or flame; low volatility; explosive air/vapor mixtures may form; NFPA Code: H 2; F 2; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; R3; R5; C&Sf; Sfl; A2; CWA; CW3; CW4; CW5; T120-a.

**MAJOR USES:** Used in the production of pesticides, resins, finishes, lacquers, printing ink, paints, adhesives, metals and gasoline.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from strong oxidizers; outside or detached storage preferred.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 5 ppm; OSHA PEL TWA 25 ppm (140 mg/m<sup>3</sup>); NIOSH REL TWA 4 ppm (23 mg/m<sup>3</sup>); IDLH 200 ppm.

**PERSONAL PROTECTION:** wear appropriate respirator, chemical-resistant gloves, safety goggles and other protective clothing; do not breathe vapor

**SPILL CLEAN-UP:** stop or control leak; use water spray to cool and disperse vapors; properly dispose of discharged material.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, an respiratory system); ingestion (headache, nausea, dizziness); contact (burning sensation, dermatitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1870 mg/kg; First aid: irrigate eyes and seek medical attention; if skin contact occurs immediately wash with water; if inhaled provide respiratory support; if ingested seek medical attention.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 14; 16.

### **LEAD COMPOUNDS (PbX, MW of Pb 207.2, formula weight varies by compound)**

**CAS/DOT #:** Pb: 7439-92-1, varies by compound

**SYNONYMS:** Lead metal, plumbum.

**PHYSICAL PROPERTIES:** Pb: bluish-gray or silvery-white, heavy, ductile solid; tarnishes upon exposure to air; insoluble in water; some Pb compounds soluble in water; MP (327.4°C, 621°F); BP (1740°C, 3164°F); LSG (11.3); VP (1.0 mm Hg at 980°C); VS (3.2 cP at 327.4°C).

**CHEMICAL PROPERTIES:** Noncombustible; strong reactions with oxidizers, hydrogen peroxide and acids; attacked by water and organic acids in the presence of oxygen; AT (not applicable); FP (not applicable); LFL (not applicable); UFL (not applicable).

**EXPOSURE ROUTES:** Inhalation (gasoline, smelters, tobacco smoke, paints and emissions); ingestion (paint chips and contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: colic; headache; insomnia; loss of appetite; vomiting; brain and kidney damage; CNS effects; gastrointestinal effects; malaise; irritability; encephalopathy; anemia; muscle and joint pains; flaccid paralysis; tremors; hallucinations; death; Chronic Risks: anemia, CNS damage; neurological symptoms; sperm count depression; low birth weight; impaired mental development; blood effects.

**HAZARD RISK:** Fire and explosion hazard when in the form of dust exposed to heat or flame; rubber gloves containing lead may ignite in nitric acid; forms explosive mixtures of finely

dispersed particles in air; decomposition emits highly toxic fumes of lead; NFPA Code: not available.

**MEASUREMENT METHODS:** Particulate filter; nitric acid/hydrogen peroxide; atomic absorption spectrometry.

**APPLICABLE REGULATIONS:** C&Sf; Sfl; CAL.

**MAJOR USES:** Used in the production of batteries, metal products, gasoline additives, pipes, solder, sheet lead, ammunition, X-ray shields, paints, ceramics, foil, cable covering, electronic devices and Babbitt metal alloys.

**STORAGE:** Keep away from strong oxidizers, strong bases and strong acids.

**FIRE FIGHTING:** Dry chemical powder or sand used with molten metals; for surrounding fires use water spray, dry chemical powder, carbon dioxide or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.15 mg/m<sup>3</sup>; OSHA PEL TWA 0.50 mg/m<sup>3</sup>; NIOSH REL TWA 0.10 mg/m<sup>3</sup>; IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and heat resistant gloves; wear chemical safety goggles; full-facepiece and self-contained breathing apparatus is recommended at a concentration of 100mg/m<sup>3</sup>; emergency showers and fire extinguishers are recommended around kilns.

**SPILL CLEAN-UP:** for water spill, neutralize with agricultural lime, crushed limestone, or sodium bicarbonate; adjust pH to neutral; remove immobilized masses of pollutants and precipitates; wet mopping, wet wiping, and wet vacuuming is recommended for dust control and for keeping dust levels down.

**HEALTH SYMPTOMS:** inhalation (weakness, insomnia, facial pallor); skin absorption (anorexia, vomiting, convulsions, malaise, permanent brain damage); ingestion (loss of appetite, gastric and liver changes).

**GENERAL COMMENTS:** First aid: immediately wash eyes with large amounts of water; for hot metal burns, cool exposed area with water; if inhaled remove to fresh air immediately.

**KEY REFERENCES:** 3; 4; 6; 7; 13; 14; 16.

### LINDANE (C<sub>6</sub>H<sub>6</sub>Cl<sub>6</sub>, 290.82)

**CAS/DOT #:** 58-89-9/UN2761

**SYNONYMS:** BHC, HCH, gamma-hexachlorocyclohexane.

**PHYSICAL PROPERTIES:** White to light yellow crystalline powder; slight musty odor; insoluble in water; MP (112.5°C, 235°F); BP (323.4°C, 614°F); LSG (1.85); VP (9.4x10<sup>-6</sup> mm Hg at 20°C) OT (12 ppm).

**CHEMICAL PROPERTIES:** Stable to heat, light and oxidation; corrosive to metals; volatile in air; incompatible with strong oxidizers; FP (not applicable); AT (not applicable); LFL (not applicable); UFL (not applicable).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Skin man TDLo 20 mg/kg for 6 weeks; EPA Group B2/C probable human carcinogen; Acute Risks: irritation of eyes, skin, nose and throat; itchiness; headache; seizures; respiratory failure; nausea; vomiting; diarrhea; tremors; weakness; anemia; convulsions; cyanosis; Chronic Risks: local sensitivity; effects on liver, blood, cardiovascular and immune systems.

**HAZARD RISK:** Noncombustible, but may dissolve in flammable liquids; hazardous decomposition emits toxic fumes of carbon monoxide, carbon dioxide, hydrogen chloride gas and phosgene gas; decomposition upon contact with alkalis produces trichlorobenzene; decomposition upon contact with powdered iron produces aluminum and zinc; NFPA Code: not available.

**MEASUREMENT METHODS:** Particulate filter/bubbler; isooctane; gas chromatography with electrolytic conductivity detection.

**APPLICABLE REGULATIONS:** C&Sf; Sfl.

**MAJOR USES:** Used as an insecticide on field crops, corn, wheat, pasture, forestry, livestock and viticulture; used as a medication (pediculicide, scabicide, ectoparasiticide and lice and scabies treatment).

**STORAGE:** Keep in a tightly closed container in a cool, dry area away from bases and metals.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder, water spray or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.5 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup>(skin); IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear dust and splash-proof safety goggles; wear a filter mask and self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate area; approach release from upwind; use water spray to knock down vapor; carbon or peat may be used as sorbents; wastes may be treated by neutralization and settling.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin nose, and throat); skin absorption (hyperirritability, central nervous system excitation, vomiting, muscle spasms, convulsions); contact (dermatitis, urticaria).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 76 mg/kg; First aid: immediately wash eyes and skin with large amounts of water; if inhaled immediately remove to fresh air and provide respiratory assistance if needed; wash out mouth with water, as long as victim is conscious.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 13; 14; 16.

**MALEIC ANHYDRIDE (C<sub>4</sub>H<sub>2</sub>O<sub>3</sub>, 98.06)**

CAS/DOT #: 108-31-6/UN2215

**SYNONYMS:** cis-Butenedioic anhydride, 2,5-furanedione, maleic acid anhydride, toxilic anhydride.

**PHYSICAL PROPERTIES:** Colorless to white needles, white lumps or pellets; irritating, choking odor; soluble in water, alcohol and dioxane; partially soluble in chloroform and benzene; incompatible with strong oxidizers, alkalis, metals, caustics and amines; reacts with water to form maleic acid; MP (53°C, 127°F); BP (202°C, 396°F); DN (1.48 g/mL at 20°C); VP (0.1 mm Hg at 25°C); VD (3.4); OT (1.9 ppm).

**CHEMICAL PROPERTIES:** Combustible; stable under normal laboratory conditions; hazardous polymerization will not occur; FP (103°C); AT (465°C); LFL (1.4%); UFL (7.1%).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin and respiratory tract; burning in larynx; reflex cough; sneezing; allergic respiratory reactions; lacrimation; skin burns and blisters; burns in digestive tract; nosebleeds; headaches; double vision; conjunctivitis; photophobia; Chronic Risks: dermatitis; chronic bronchitis; upper respiratory tract infection; pulmonary edema.

**HAZARD RISK:** Combustible, but may be difficult to ignite; caustic with water contact; fire and explosion hazard when in contact with strong oxidizers; corrosive; explosion hazard when dust cloud ignited by flame or spark; decomposition emits toxic vapors of carbon monoxide and carbon dioxides; NFPA Code: H 3; F 1; R 1.

**MEASUREMENT METHODS:** Bubbler; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** C&Sf; Sf1; Sf3; CWA; CW1; CW2; T120-a; A1; R4; R6.

**MAJOR USES:** Used in the production of captan, pesticides, resins, oils, fats, plasticizers, surfactants, copolymers and malathion.

**STORAGE:** Keep in a tightly closed container away from moisture; do not reuse container.

**FIRE FIGHTING:** Use alcohol foam or carbon dioxide; do not use chemical powder or loaded stream media.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.25 ppm; OSHA PEL TWA 0.25 ppm (1mg/m<sup>3</sup>) NIOSH REL TWA 0.25 ppm (1 mg/m<sup>3</sup>) IDLH 10mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear NIOSH/MSHA-approved respirator, chemical-resistant gloves, safety goggles and other protective clothing.

**SPILL CLEAN-UP:** ventilate area; sweep small quantities onto paper or other suitable material, place in a tightly sealed container, and cautiously ignite in a safe area; dissolve in a flammable solvent and atomize in a suitable combustion chamber.

**HEALTH SYMPTOMS:** inhalation (coughing, sneezing, throat irritation); skin absorption (severe eye irritation, photophobia, double vision); contact (severe skin irritation and redness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 400 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs immediately remove clothing; if inhaled remove to fresh air and provide oxygen and resuscitation as needed; if ingested wash out mouth with water and call physician.

**KEY REFERENCES:** 4; 5; 6; 7; 10; 11; 13; 14; 16.

### **MANGANESE COMPOUNDS (MnX, MW of Mn 54.94, formula weight varies by compound)**

**CAS/DOT #:** Mn: 7439-96-5

**SYNONYMS:** Colloidal manganese, tronamang.

**PHYSICAL PROPERTIES:** Mn: Silver or gray-white, lustrous, brittle metal; small dust particles can become suspended in air; MP (1245°C, 2273°F); BP (2150°C, 3902°F); LSG (7.43); VP (1 mm Hg at 1292°C).

**CHEMICAL PROPERTIES:** Superficially oxidized upon exposure to air; reacts with diluted mineral acids, sodium or potassium bicarbonate; slightly attacked by steam; reacts with carbon, phosphorus, antimony and arsenic upon heating; reduces most metallic oxides in powder form upon heating; reacts with water or steam to produce hydrogen.

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated food and water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation man TCl<sub>o</sub> 2300 g/m<sup>3</sup>; EPA Group D not classifiable as to human carcinogenicity; Acute Risks: abdominal pain; cough; shortness of breath; bronchitis; pneumitis; symptoms take 1 to 3 years to develop; Chronic Risks: CNS effects; weakness; lethargy; speech disturbances; mask-like face; neurological and neuropsychiatric disturbances (manganism); bronchitis; pneumonia; Parkinsonian slapping gait; impotence; leg cramps; twitching; paralysis.

**HAZARD RISK:** Moderate fire and explosive hazard in the forms of dust or granular powder in air when exposed to flame; mixtures may explode when heated; burns in nitrogen gas above 200°C; fire and explosion hazard when in contact with water; NFPA Code: not available.

**MEASUREMENT METHODS:** Particulate filter; acid; inductively coupled plasma.

**APPLICABLE REGULATIONS:** C&Sf; Sf3.

**MAJOR USES:** Used in the manufacture of dry-cell batteries, steel, high-purity salt, railway points and crossings, matches, fireworks, animal feed, glazes, varnishes, ceramics and nutritional supplements.

**STORAGE:** Keep in a dry area away from acids, oxidizers and halogen gases.

**FIRE FIGHTING:** Use special sand or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (dust and compounds) 5 mg/m<sup>3</sup>; ACGIH TLV STEL (fume) 3 mg/m<sup>3</sup>; ACGIH TLV (fume) 1 mg/m<sup>3</sup>; OSHA PEL TWA (fume) 1 mg/m<sup>3</sup>; OSHA PEL STEL (fume) 3 mg/m<sup>3</sup>; OSHA PEL (dust and compounds) 5 mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; NIOSH REL STEL 3 mg/m<sup>3</sup>; IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use dust explosion-proof electrical equipment and lighting; for extra personal protection, use a P2 filter respirator for harmful particles; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep spilled substance into containers; collect remaining material, then remove to a safe place; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (headache, vomiting, nausea, abdominal pain); skin absorption (pulmonary damage, central nervous system damage); contact (eye irritation, skin irritation, vesiculation).

**GENERAL COMMENTS:** First aid: immediately wash eyes and skin with large amounts of water; remove to fresh air immediately.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 16.

### **MERCURY COMPOUNDS (HgX, MW of Hg 200.59, formula weight varies by compound)**

**CAS/DOT #:** Hg: 7439-97-6/UN2809

**SYNONYMS:** Colloidal mercury; quick silver.

**PHYSICAL PROPERTIES:** Hg: Silver-white, mobile liquid; heavy; odorless; insoluble in water, alcohol and ether; soluble in boiling sulfuric acid; MP (-38.89°C, -38.0°F); BP (356.9°C, 674.4°F); DN (13.534 g/mL at 25°C); VS (1.554cP at 20°C); VP (0.002 mm Hg at 25°C); ST (484 dynes/cm).

**CHEMICAL PROPERTIES:** Hg: Forms alloys with most metals except iron; attacks most metals to form amalgams; reacts violently with alkali metals, acetaldehyde, azides, ammonia gas, chlorine, chlorine dioxide, sodium carbide and ethylene oxide; noncombustible liquid; FP (not applicable); AT (not applicable); LFL (not applicable) UFL (not applicable).

**EXPOSURE ROUTES:** Inhalation (old cans of paint); ingestion (fish, meat, grains and dental fillings); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation man TDLo 44,300 g/m<sup>3</sup> Hg for 8 hours; skin man TDLo 129 mg/kg for 5 hours; EPA Group D not classifiable as to human carcinogenicity (Hg); EPA Group C possible human carcinogen (inorganic and methyl mercury); Acute Risks: chest pains; respiratory effects; lung effects; vomiting; severe abdominal pain; kidney damage; suicidal tendencies; hallucinations; Chronic Risks: irritability; insomnia; severe salivation; jerky gait; speech difficulty; vision problems; CNS damage.

**HAZARD RISK:** Many compounds explosively unstable; decomposition emits toxic fumes of Hg; NFPA Code: not available.

**MEASUREMENT METHODS:** Hydrar sorbent tube; acid; cold atomic absorption spectrometry.

**APPLICABLE REGULATIONS:** C&Sf; Sf3.

**MAJOR USES:** Used in the production of thermometers, batteries, lamps, barometers pharmaceuticals; lubrication oils, dental amalgams, laxatives, latex paint, skin-lightening cream and soaps.

**STORAGE:** Keep in plastic, glass or steel container in a cool, well-ventilated area.

**FIRE FIGHTING:** Use water spray, fog or foam; use water spray to cool containers.

**EXPOSURE GUIDELINES:** aryl and inorganic: ACGIH TLV TWA 0.1mg(Hg)/m<sup>3</sup> (skin); OSHA PEL CL 0.1 mg (Hg)/m<sup>3</sup> (skin); NIOSH REL CL 0.1 mg/m<sup>3</sup> (skin); IDLH 10mg (Hg)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing (suits, gloves, footwear headgear, etc.); wear chemical safety goggles and face shield; full facepiece respiratory protection is recommended; eye wash fountains should be provided in the immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; use a specialized charcoal-filtered vacuum or suction pump to collect all visible material; sprinkle the entire area of the spill with elemental zinc powder; use a 5-10% sulfuric acid solution to dampen the zinc powder to create a paste-like consistency; after paste dries to a light gray color, it may be swept up and disposed of properly residual material is removed with soap and water.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (central nervous system damage, kidney damage, weight loss).

**GENERAL COMMENTS:** First aid: wash eyes and skin with water; remove to fresh air.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 16; 17.

### **METHANOL (CH<sub>4</sub>O, 32.05)**

**CAS/DOT #:** 67-56-1/UN1230

**SYNONYMS:** Carbinol, columbian spirits; methyl alcohol; wood alcohol.

**PHYSICAL PROPERTIES:** Clear, colorless, mobile liquid; pungent odor; soluble in water, alcohol and ethers; MP (-97.8°C, -144°F); BP (64°C, 147°F); LSG (0.8); VD (1.1); VP (92 mm Hg at 20°C); ST (22.61 mN/m at 20°C).

**CHEMICAL PROPERTIES:** Forms azeotropes with many compounds; incompatible with strong oxidizers; flammable; highly polar; burns with blue flame; AT (867°F); FP (11°C); LFL (6.0%); UFL (36%).

**EXPOSURE ROUTES:** Inhalation (automobile exhaust); ingestion (contaminated food and ingestion of liquid); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TDLo 300 ppm; Acute Risks: irritation of eyes, skin, mucous membranes and respiratory tract; headache; drowsiness; vertigo; visual disturbances; optic nerve damage; blindness; gastrointestinal effects; convulsions; Chronic Risks: headache, giddiness, insomnia, conjunctivitis, blindness; gastrointestinal effects.

**HAZARD RISK:** Dangerous fire risk; explosive vapor/air mixtures; fire and explosion hazard when reacts with strong oxidizers; decomposition emits acrid smoke and fumes of carbon monoxide and carbon dioxide; NFPA Code: H 1; F 3; R 0.

**MEASUREMENT METHODS:** Silica gel; water; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; S10; A1.

**MAJOR USES:** Used in the production of antifreeze, acids, vitamins, hormones, plastics, pharmaceuticals and gas; treatment against onion smut and Dutch elm disease.

**STORAGE:** Keep in cool, dry, well-ventilated area away from fire hazards.

**FIRE FIGHTING:** Use dry chemical powder, foam or carbon dioxide; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm; ACGIH TLV STEL 250 ppm (skin); OSHA PEL TWA 200 ppm (260mg/m<sup>3</sup>); OSHA PEL STEL 250 ppm (skin); NIOSH REL TWA 200 ppm (260 mg/m<sup>3</sup>); NIOSH REL STEL 250 ppm (325 mg/m<sup>3</sup>)(skin); IDLH 6000 ppm.

**PERSONAL PROTECTION:** wear rubber protective clothing, polyvinyl plastic or neoprene aprons, rubber boots, and chemical-resistant gloves; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** apply a fluorocarbon water foam to spill to diminish vapor; absorb as much as possible with noncombustible materials such as hycar and carbopol; materials such as polyester, urethane foam, and seagoing epoxy putty are recommended for plugging leaking containers of methanol; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, breathing difficulty, loss of consciousness); skin absorption (nausea, drowsiness, vertigo); ingestion (vomiting, gastric disturbances, eye damage).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5628 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs immediately remove clothing; if inhaled remove to fresh air and give resuscitation or oxygen as needed; if ingested wash out mouth and immediately seek medical attention.

**KEY REFERENCES:** 4; 5; 6; 7; 10; 13; 14; 16.

### **METHOXYCHLOR (C<sub>16</sub>H<sub>15</sub>Cl<sub>3</sub>O<sub>2</sub>, 345.66)**

**CAS/DOT #:** 72-43-5/UN2761

**SYNONYMS:** 1,1'-(2,2,2-Trichloroethylidene)bis(4-methoxy-)benzene, dimethoxy-DDT.

**PHYSICAL PROPERTIES:** White to orange crystalline solid; insoluble in water; soluble in alcohol and acetone; MP (78°C, 172°F); BP (decomposes); DN (1.41 lb/ft<sup>3</sup> at 25°C); VD (12 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Resistant to heat and combustion; incompatible with alkaline materials and oxidizers; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated water and contaminated food); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes and skin; trembling; mild kidney and liver damage; convulsions; Chronic Risks: CNS and kidney damage; suspected carcinogen.

**HAZARD RISK:** Slight fire hazard; combustible solid but difficult to burn; decomposition emits toxic fumes of chlorine gas, carbon dioxide and carbon monoxide; NFPA Code: not available.

**MEASUREMENT METHODS:** Particulate filter; isooctane; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CAA; CA2; CWA; CW1; S1; S24; S32; S50-b; S61; S62; FIFRA; F2; F4; R5; R6; C&Sf; Sfl; S3; A1.

**MAJOR USES:** Used in the production of insecticides and ectoparasiticide; DDT replacement.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use dry chemical powder, foam or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>; NIOSH REL TWA potential occupational carcinogen; IDLH 5000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear special protective clothing, including chemical-resistant gloves; use chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** stop or control leak if possible; use water spray to cool and disperse vapors absorb liquid in noncombustible materials such as dry earth, sand or vermiculite; shovel solids into suitable dry containers.

**HEALTH SYMPTOMS:** inhalation or skin absorption (muscle weakness, liver dysfunction); skin contact (chloracne, tremors, convulsions, eye and skin burns).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5000 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs immediately remove clothing; if inhaled remove to fresh air and provide oxygen or artificial respiration as needed; if ingested wash out mouth and seek medical attention.

**KEY REFERENCES:** 4; 5; 6; 7; 11; 14; 16.

**METHYL BROMIDE (CH<sub>3</sub>Br, 94.95)**

**CAS/DOT #:** 74-83-9/UN1062

**SYNONYMS:** Bromomethane, brom-o-gas, iscobrome, zytox.

**PHYSICAL PROPERTIES:** Clear, colorless, easily liquefied gas or highly volatile liquid; chloroform-like odor; burning taste; slightly soluble in water; miscible with most organic solvents; MP (-93°C, -135°F); BP (4°C, 39°F); LSG (1.73); VD (3.27); VP (1250 mm Hg at 20°C); ST (0.0224 N/m).

**CHEMICAL PROPERTIES:** Will not polymerize; stable; not ordinarily combustible; forms spontaneously flammable mixtures with aluminum; FP (not applicable); AT (537°C); LFL (10%); UFL (16%).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human LCLo 60,000 ppm for 2 hours; EPA Group D not classifiable as to human carcinogenicity; Acute Risks: destructive to skin, eyes, mucous membranes and respiratory tract; dermatitis; skin lesions; spasm; pulmonary edema; shortness of breath; respiratory effects; vomiting; blurred vision; confusion; Chronic Risks: effects on eyes, liver, kidney, lungs; cumulative effects.

**HAZARD RISK:** Moderate fire hazard; not ordinarily combustible but will burn in presence of high heat or strong oxidizers; decomposition emits fumes of carbon monoxide, carbon dioxide and hydrogen bromide; NFPA Code: H 3; F 1; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; C&Sf; Sf1; Sf2; FIFRA; F1; R2; U029; R4; R5; A1.

**MAJOR USES:** Fumigant to control rats, insects, fungus and weeds; herbicide; wool degreaser; refrigerant; fire extinguishing agent; methylating agent.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from active metals; outside or detached storage preferred.

**FIRE FIGHTING:** Do not attempt to extinguish burning gas if flow cannot be shut off immediately; use water or fog to keep fire-exposed containers cool.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5ppm (skin); OSHA PEL TWA 5ppm (skin), OSHA PEL CL 20 ppm (80 mg/m<sup>3</sup>) (skin); NIOSH REL TWA reduce to lowest feasible level; IDLH 250 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves constructed from tetrafluoroethylene polymer; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; evacuate danger area; ventilate area of leak or spill; use fine water spray to disperse vapors; water jet should never be directed on liquid; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (headache, vomiting, nausea, abdominal pain); skin absorption (pulmonary damage, central nervous system damage); contact (eye irritation, skin irritation, vesiculation).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 214 mg/kg; First aid: immediately wash eyes with water; if skin contact occurs remove clothes and wash with water; remove to fresh air; if ingested wash out mouth with water; keep under medical supervision.

**KEY REFERENCES:** 1; 2; 4; 5; 6; 7; 9; 10; 11; 13; 14; 16.

### **METHYL CHLORIDE (CH<sub>3</sub>Cl, 54.49)**

**CAS/DOT #:** 74-87-3/UN1063

**SYNONYMS:** Chloromethane, monochloromethane.

**PHYSICAL PROPERTIES:** Colorless gas; faint, sweet odor; slightly soluble in water; soluble in organic solvents; MP (-97°C, -143°F); BP (-24°C, -11°F); VD (1.8); DN (0.918 g/mL at 20°C); VP (3796 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Attacks chemically active metals such as potassium, powdered aluminum, zinc and magnesium; reacts with water to form hydrochloric acid; AT (631°C); FP(-50°F); LFL (8.1); UFL (17.4).

**EXPOSURE ROUTES:** Inhalation (wood burning, swimming pools, tobacco smoke and aerosol); ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human LCLo 20,000 ppm for 2 hours; Acute Risks: irritation of eyes, skin, mucous membranes and upper respiratory tract; dizziness; visual disturbances; slurred speech; frostbite; liver and kidney damage; narcosis; coma; Chronic Risks: confusion, vomiting, abdominal pains, delirium, effects on lungs, liver, kidneys and heart; convulsions; coma; possible carcinogen.

**HAZARD RISK:** Dangerous fire risk; highly flammable; corrosive vapors; explodes on contact with interhalogens; decomposition emits fumes of carbon monoxide, carbon dioxide, hydrogen chloride and phosgene gases; NFPA Code: H 1; F 4; R 0.

**MEASUREMENT METHODS:** Charcoal tube; dichloromethane; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sfl; FIFRA; F7; R2; R3; CWAI CW4; CW5; T799-5055; A1; A2; A5.

**MAJOR USES:** Used in the production of silicones, agricultural chemicals, paint, rubber and glazes; refrigerant; cooling media; food additive; dispersing agent; thickening agent.

**STORAGE:** Keep in a fireproof area if in building.

**FIRE FIGHTING:** Use dry chemical powder, foam or carbon dioxide; if possible let fire burn itself out; fight fire from sheltered position; use water spray to cool containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; ACGIH TLV STEL 100 ppm; OSHA PEL TWA 100 ppm; OSHA PEL CL 200 ppm; OSHA PEL 300 ppm/5M max peak/3H; IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; use fine water spray to disperse vapors; water jet should never be directed on liquid; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (convulsions, nausea, vomiting, narcotic effects, dizziness, drowsiness, effects on the eye); contact (anesthesia through freezing of tissues on evaporation of methyl chloride).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1800 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing; if inhaled remove to fresh air and give resuscitation and oxygen as needed; if ingested wash out mouth and call physician.

**KEY REFERENCES:** 4; 5; 6; 7; 10; 11; 13; 14; 16.

### **METHYL CHLOROFORM (C<sub>2</sub>H<sub>3</sub>Cl<sub>3</sub>, 133.4)**

**CAS/DOT #:** 71-55-6/UN2831

**SYNONYMS:** Chloroethene, 1,1,1-trichloroethane, 1,1,1-TCE, tri-ethane.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; chloroform-like odor; insoluble in water; miscible with acetone, benzene, methanol and carbon disulfide; MP (-30°C, -22°F); BP (74°C, 165°F); LSG (1.34); VS (0.858 cP at 25°C); ST (25.4 dynes/cm); VP (100 mm Hg at 20°F); OT (44 ppm).

**CHEMICAL PROPERTIES:** Generally stable; combustible, but burns with difficulty; reacts violently with acetone, liquid and gaseous oxygen, aluminum, strong caustics, chemically active metals, sodium and sodium hydroxide; attacks natural rubber; FP (not available); AT (537°C); LFL (7.0%); UFL (16.0%).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation man TCl<sub>o</sub> 200 ppm for 4 hours; oral man TDLo 670 mg/kg; Acute Risks: irritation of skin and eyes; vomiting; diarrhea; CNS depression; narcosis; respiratory failure; ataxia; unconsciousness; cardiac arrest; death; Chronic Risks: skin defatting; fatty degeneration of liver; growth depression; ventricular arrhythmias.

**HAZARD RISK:** Explosion of vapors when exposed to high energy; combustion emits fumes of hydrogen chloride and phosgene; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** S1; S32; S61; S62; S10; FIFRA; R1; R3; R5; R9; C&Sf; Sf1; Sf3; CWA; CW4; CW5; T120.a-d; T799-5000.

**MAJOR USES:** Used in the production of waxes, tar, organic compounds, inks, lubricants, pesticides, aerosols and coatings; extraction solvent; coolant; fumigant.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from oxidizers, ammonia, active metals, open flame, arc welding, and combustibles.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 350 ppm; OSHA PEL TWA 350 ppm (1900 mg/m<sup>3</sup>); NIOSH REL CL 350 ppm (1900 mg/m<sup>3</sup>); IDLH 700 ppm.

**PERSONAL PROTECTION:** Wear neoprene or polyvinyl alcohol suit or aprons for splash protection; neoprene or polyvinyl alcohol type gloves plus neoprene safety shoes are also recommended; chemical safety goggles are necessary; enclose operations and use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** Stop or control leak if possible; ventilate area of spill or leak; collect liquid in sealable containers or absorb in dry earth, sand, or vermiculite.

**HEALTH SYMPTOMS:** Inhalation (dizziness, difficult breathing, asphyxiation, loss of equilibrium, in coordination, loss of consciousness, irritates eyes, nose and throat); eyes (slightly irritating and lachrymatory); skin (defatting action, resulting in dermatitis); ingestion (feeling of nausea, other symptoms parallel those of inhalation).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 9600 mg/kg; First aid: immediately wash eyes with water; if skin contact occurs wash skin with water and soap; if ingested wash out mouth with water as long as victim is conscious.

**KEY REFERENCES:** 4; 5; 6; 7; 10; 11; 13; 14; 16.

### **METHYL ETHYL KETONE (C<sub>4</sub>H<sub>8</sub>O, 72.12)**

**CAS/DOT #:** 78-93-3/UN1193

**SYNONYMS:** 2-Butanone, ethyl methyl ketone, methyl acetone.

**PHYSICAL PROPERTIES:** Clear, colorless, volatile liquid; acetone-like odor; soluble in water; miscible with alcohol, ether and fixed oils; MP (-85.9°C, -122.6°F); BP (80°C, 176°F); VS (0.40 cP at 25°C); VP (71.2 mm Hg at 25°C); LSG (0.8); VD (2.5).

**CHEMICAL PROPERTIES:** Flammable; reacts vigorously with strong oxidizers, amines, ammonia, inorganic acids, caustics, copper, isocyanates and pyridines; AT (404°C); FP (16°F); LFL (1.4); UFL (11.4).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TCl<sub>o</sub> 100 ppm; Acute Risks: irritation of eyes, skin, mucous membranes and respiratory tract; abdominal cramps; confusion; CNS depression; narcosis; vomiting; headache; dizziness; dermatitis; gastrointestinal problems; Chronic Risks: Effects on CNS, liver and respiratory system; skin defatting; dermatitis.

**HAZARD RISK:** Flammable liquid; moderate fire hazard; container explosion may occur under fire conditions; forms explosive vapor/air mixtures; vapor is heavier than air and may travel around the ground, then flash back; distant ignition possible; NFPA Code: H 1; F 3; R 0.

**MEASUREMENT METHODS:** Ambersorb tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** C&Sf; Sfl; R3; A1.

**MAJOR USES:** Used in the production of resins, cleaning fluids, vinyl films, adhesives, paint removers, cements, smokeless powder and nitrocellulose.

**STORAGE:** Keep in a cool area away from heat, sparks, strong acids, strong oxidizers and open flame; outside or detached storage preferred.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200ppm; STEL 300ppm; OSHA PEL TWA 200ppm (590mg/m<sup>3</sup>); STEL 300ppm; NIOSH EL (ketones) TWA 200ppm (590mg/m<sup>3</sup>); STEL 300ppm (885mg/m<sup>3</sup>); IDLH 3000ppm.

**PERSONAL PROTECTION:** wear protective clothing and chemically resistant gloves; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use air stripping to provide removal at first-order kinetic rates; absorb as much as possible with materials such as dry earth or sand; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes and skin); skin absorption (dizziness, nausea and vomiting).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2737 mg/kg; First aid: immediately rinse eyes with water; if inhaled remove to fresh air; if ingested wash out mouth with water as long as victim is conscious.

**KEY REFERENCES:** 4; 5; 6; 7; 10; 11; 13; 14; 16.

## **METHYL HYDRAZINE (CH<sub>6</sub>N<sub>2</sub>, 46.1)**

**CAS/DOT #:** 60-34-4/UN1244

**SYNONYMS:** Hydrazomethane, MMY, monomethylhydrazine.

**PHYSICAL PROPERTIES:** Colorless liquid; ammonia-like odor; hygroscopic; fuming; soluble in water; MP (-52°C, -62°F); BP (88°C, 190°F); VP (38 mm Hg at 20°C); LSG (0.87); VD (2); OT (2.1 ppm).

**CHEMICAL PROPERTIES:** Unstable; flammable liquid; may spontaneously combust in air; reacts with copper, copper alloys, lead, manganese, nitric acid, oxygen, strong oxidizers, peroxides and porous materials such as earth, asbestos, wood and cloth; FP (17°F); AT (385°F); LFL (2.5%); UFL (97%).

**EXPOSURE ROUTES:** Inhalation; ingestion (mushroom); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Risk Level nonthreshold category; EPA Group B2 probable human carcinogen; Acute Risks: destructive to skin, eyes, mucous membranes and respiratory tract; burning sensation; diarrhea; ataxia; cyanosis; shortness of breath; convulsions; liver and kidney damage; Chronic Risks: impaired function of kidney and, liver; effects on blood and spleen.

**HAZARD RISK:** Dangerous fire hazard; may spontaneously combust in air; many chemical reactions involving methyl hydrazine result in fire or explosion; forms explosive vapor/air mixtures; decomposition emits carbon monoxide, carbon dioxide and nitrogen oxides; NFPA Code: H 4; F 3; R 2.

**MEASUREMENT METHODS:** Bubbler; phosphoric acid; visible spectrophotometry.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; P068; R4; R7; R8; A1.

**MAJOR USES:** High energy fuel in rocket fuel, fuel for small electrical power generators; solvent; chemical intermediate.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from acids, oxidizers, halogens, air, heat, porous materials and open flame; store under nitrogen; detached or outside preferred.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers; fight fire from sheltered position.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 0.2 ppm (0.38 mg/m<sup>3</sup>), suspected human carcinogen; OSHA PEL CL 0.2 ppm (0.35 mg/m<sup>3</sup>)(skin); NIOSH REL CL 0.4 ppm (0.08 mg/m<sup>3</sup>/2H); IDLH 20 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use explosion-proof electrical equipment and lighting; in high vapor concentrations use self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill use water spray to cool and disperse vapors; collect leaking liquid in sealable containers; absorb remaining liquid with noncombustible materials (e.g., dry earth, sand, vermiculite), and remove to a safe place; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (bluish discoloration of skin, cough, dizziness, headache, labored breathing, burning sensation, convulsions, nausea, vomiting); skin contact (redness, pain, blisters, may cause allergic skin reactions); skin absorption (tremors, convulsions, muscular incoordination, skin sensitization); eye contact (severe deep burns, redness, pain); ingestion (abdominal cramps, nausea, vomiting, diarrhea, burning sensation, weakness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 32 mg/kg; First aid: wash eyes and skin with water; seek medical attention.

**KEY REFERENCES:** 1; 2; 4; 5; 6; 7; 9; 10; 11; 12; 13; 14; 16.

**METHYL IODIDE (CH<sub>3</sub>I, 141.94)****CAS/DOT #:** 74-88-4/UN2644**SYNONYMS:** Iodomethane, monoidomethane.**PHYSICAL PROPERTIES:** Clear, colorless liquid; turns yellow, red or brown on exposure to light or moisture; ether-like odor; soluble in water; miscible with alcohol and ether; MP (-64°C, -83°F); BP (42.5°C, 109°F); DN (2.279 g/mL at 20°C); VP (7.89 psi at 20°C); VD (4.89).**CHEMICAL PROPERTIES:** Hazardous polymerization will not occur; noncombustible; reacts violently with oxygen; FP (not applicable); AT (not applicable); LFL (not applicable); UFL (not applicable).**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.**HUMAN HEALTH RISKS:** Skin human 1g for 10 minutes; Acute Risks: irritation of skin; destructive to mucous membranes and upper respiratory tract; nausea; weakness; narcosis; vertigo; convulsions; blistering; ataxia; slurred speech; drowsiness; Chronic Risks: carcinogen; reproductive disorders; effects eyes, skin, respiratory system and CNS.**HAZARD RISK:** Stable under normal conditions; explosive reactions with trialkylphosphines and silver chlorite; decomposition emits toxic fumes of carbon dioxide, hydrogen iodide and iodine; NFPA Code: not available.**MEASUREMENT METHODS:** Charcoal tube; toluene; gas chromatography with flame ionization detection.**APPLICABLE REGULATIONS:** C&Sf; Sfl; R3.**MAJOR USES:** Used in the production of pharmaceuticals, pesticides, fire extinguishers and fumigants.**STORAGE:** Keep in a tightly closed container away from moisture in a cool, dry area; light sensitive.**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (skin); OSHA PEL TWA 5 ppm (28 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10 mg/m<sup>3</sup> reduce to lowest level; IDLH 100 ppm.**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus.**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; use fine water spray to disperse vapors; water jet should never be directed on liquid; remove all sources of ignition.**HEALTH SYMPTOMS:** inhalation (coughing, wheezing, burning sensation, shortness of breathing); skin absorption (nausea, vomiting, vertigo); contact (skin blistering).

**GENERAL COMMENTS:** Oral rat LDLo 150 mg/kg; First aid: immediately rinse eyes with water; if inhaled remove to fresh air; if ingested wash out mouth with water as long as victim is conscious.

**KEY REFERENCES:** 4; 5; 6; 7; 13; 14; 16.

### **METHYL ISOBUTYL KETONE (C<sub>6</sub>H<sub>12</sub>O, 100.18)**

**CAS/DOT #:** 108-10-1/UN1245

**SYNONYMS:** Hexone, 4-methyl-2-pentanone.

**PHYSICAL PROPERTIES:** Colorless liquid; pleasant, fruity odor; slightly soluble in water; miscible with alcohol and ether; MP (-80.2°C, -112°F); BP (118°C, 244°F); LSG (0.8); VD (3.5); VP (15 mm Hg at 20°C); OT (0.10 ppm).

**CHEMICAL PROPERTIES:** Hazardous polymerization will not occur; incompatible with strong oxidizers, reducers, potassium tert-butoxide and strong bases; AT (840°F); FP (64°F); LFL (1.2%); UFL (8.0%).

**EXPOSURE ROUTES:** Inhalation (exhaust gas); ingestion (contaminated water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Eye human 200 ppm for 15 minutes; EPA Group D not classifiable as to human carcinogenicity; Acute Risks: irritation of eyes and mucous membranes; weakness; headache; vomiting; dizziness; loss of coordination; narcosis; blurred vision; coma; death; Chronic Risks: burning in eyes; weakness; insomnia; intestinal pain; enlargement of liver.

**HAZARD RISK:** Flammable liquid; fire hazard when exposed to heat, flame and oxidizers; ignites on contact with potassium-tert-butoxide; moderately explosive in vapor form; NFPA Code: H 2; F 3; R 1.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S3; S10; C&Sf; Sf1; Sf3; U161; R2; R3; T120-a; T799-5000; CAL.

**MAJOR USES:** Used as a solvent in gums, resins, paints, varnishes, lacquers, alcohols and synthetic flavoring.

**STORAGE:** Keep in a tightly closed container in a cool, dry area away from heat, sparks, open flame.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH LV TWA 50 ppm; ACGIH TLV STEL 75 ppm; OSHA PEL TWA 100 ppm (410mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (205 mg/m<sup>3</sup>); NIOSH REL STEL 75 ppm (300 mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (defatting, dermatitis); contact (redness of eyes, tearing, blurred vision).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2080 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothes and wash with water; if inhaled remove to fresh air and provide respiratory assistance as needed; if ingested wash out mouth with water as long as victim is conscious.

**KEY REFERENCES:** 2; 4; 5; 6; 7; 10; 13; 14; 16.

### **METHYL ISOCYANATE (C<sub>2</sub>H<sub>3</sub>NO, 57.05)**

**CAS/DOT #:** 624-83-9/UN2480

**SYNONYMS:** Isocyanate methyl methane, isocyanic acid methyl ester.

**PHYSICAL PROPERTIES:** Colorless liquid; sharp, pungent odor; MP (-17°C, -1°F); BP (39°C, 102°F); VD (1.97); LSG (0.987); VS (0.127 cP at 20°C); VP (348 mm Hg at 20°C); OT (2.1 ppm).

**CHEMICAL PROPERTIES:** Polymerizes easily; mixtures usually contain polymerization inhibitors; reactive with water, alcohols, acids, amines, strong bases, copper, iron, tin, strong oxidizers and heat; attacks some rubber, plastics and coatings; FP (19°F); AT (994°F); LFL (5.3%); UFL (26%).

**EXPOSURE ROUTES:** Inhalation (tobacco smoke); ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TCLo 2 ppm; EPA Risk Level not classifiable; Acute Risks: destructive to skin, eyes and mucous membranes; respiratory ailments; headaches; cyanosis; vomiting; gastritis; sweating; chills; fever; liver and kidney damage; Chronic Risks: pelvic inflammatory disease; spontaneous abortions.

**HAZARD RISK:** Dangerous fire hazard when heated or in contact with water or catalysts; unstable; forms explosive vapor/air mixtures; vapor is heavier than air and may travel around the ground, then flash back; distant ignition is possible; decomposition emits fumes of carbon monoxide, carbon dioxide, nitrogen oxides and hydrogen cyanide; NFPA Code: H 2; F 3; R 3.

**MEASUREMENT METHODS:** XAD tubes; acetonitrile; high pressure liquid chromatography with fluorescence detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf2; Sf3; R4; P064; A1.

**MAJOR USES:** Used in the manufacture of carbamate insecticides and herbicides.

**STORAGE:** Keep in a tightly closed, stainless steel container in a cool, dry area away from heat and open flame; separate from all other substances; store under nitrogen.

**FIRE FIGHTING:** Use carbon dioxide or dry chemical powder only; do not use hydrous agents; use water spray to cool exposed containers but avoid direct contact; fight fire from sheltered position.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.02 ppm (skin); OSHA PEL TWA 0.02 ppm (0.05mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.02 ppm (0.05mg/m<sup>3</sup>)(skin); IDLH 3ppm.

**PERSONAL PROTECTION:** wear rubber apron, sleeves, and other protective clothing; wear long chemical-resistant gauntlet gloves; wear chemical safety goggles and protective face shield; wear positive pressure self-contained apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (spasm, inflammation and edema of the larynx and bronchi, chemical pneumonitis, pulmonary edema, conjunctiva irritation, and olfactory changes); skin absorption (blindness, lung damage, emphysema, gynecological effects); contact (mucous membrane irritant, respiratory sensitizer, skin damage).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 51.5 mg/kg; First aid: wash eyes and skin with water; remove to fresh air; if ingested wash out mouth with water if victim is conscious.

**KEY REFERENCES:** 1; 2; 4; 5; 6; 7; 9; 10; 12; 13; 14; 16.

### **METHYL METHACRYLATE (C<sub>5</sub>H<sub>8</sub>O<sub>2</sub>, 100.13)**

**CAS/DOT #:** 80-62-6/UN1247

**SYNONYMS:** Acrylic acid, 2-methyl-methyle ester, methacrylsaeuremethyl ester, 2-methyl methyl ester.

**PHYSICAL PROPERTIES:** Colorless liquid; fruity odor; insoluble in water; soluble in acetone; MP (-48°C, -55°F); BP (100°C, 213°F); LSG (0.94); VP (29 mm Hg at 20°C); VD (3.45).

**CHEMICAL PROPERTIES:** May polymerize in contact with heat, oxidizers or ultra-violet light; often contains polymerization inhibitor such as hydroquinone; reacts with nitrates, oxidizers, peroxides, water and strong alkalis; FP (50°F); AT (815°F); LFL (1.7%); UFL (8.2%).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TCLo 125 ppm; Acute Risks: destructive to mucous membranes and upper respiratory tract; burning sensation; redness of skin; dermatitis; respiratory ailments; headache; vomiting; Chronic Risks: sleeping disturbances; asthma; kidney and liver lesions; cardiovascular effects.

**HAZARD RISK:** Very dangerous fire hazard; ignites on contact with benzoyl peroxide; explosive vapor is heavier than air and may travel around the ground, then flash back; distant ignition is possible; forms explosive vapor/air mixtures; decomposition emits acrid smoke and irritating fumes; NFPA Code: H 2; F 3; R 2.

**MEASUREMENT METHODS:** XAD tubes; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CWA; CW1; CW2; C&Sf; Sf1; Sf3; R3; R4; R5; T225-9975.

**MAJOR USES:** Used in the production of bone cement, lighting fixtures, skylights, plumbing and bathroom fixtures, molding powder, building panels and resins.

**STORAGE:** Keep in a tightly closed container in a cool, dry, well-ventilated area away from oxidizers, peroxides, other initiators.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; OSHA PEL TWA 100 ppm (410mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (410mg/m<sup>3</sup>); IDLH 1000ppm.

**PERSONAL PROTECTION:** wear full protective clothing including aprons, boots, sleeves, etc.; wear long chemical resistant gauntlet gloves; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb in noncombustible materials such as dry earth or sand; flush remaining methyl methacrylate with large amounts of water but not into confined spaces such as sewers because of danger of explosive polymerization; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (sleep effects, excitement, anorexia, decrease in blood pressure, nausea, vomiting, headache, dizziness, unconsciousness); contact (burning sensation, dermatitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 7872 mg/kg; First aid: rinse eyes with water; remove to fresh air; if ingested wash out mouth with water.

**KEY REFERENCES:** 4; 5; 6; 7; 10; 13; 14; 16.

### **METHYL tert BUTYL ETHER (C<sub>5</sub>H<sub>12</sub>O, 88.17)**

**CAS/DOT #:** 1634-04-4/UN not available

**SYNONYMS:** 2-Methoxy-w-methylpropane, methyl 1,1-dimethylethyl ether; MTBE.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; slightly soluble in water; BP (54°C, 129°F); VP (245 mm Hg at 25°C); LSG (0.74).

**CHEMICAL PROPERTIES:** Hazardous polymerization will not occur; highly flammable liquid; reacts vigorously with strong oxidizers; unlike other ethers, usually does not form peroxides; FP (14°F); AT (224°C); LFL (1.6%); UFL (15.1%).

**EXPOSURE ROUTES:** Inhalation (gasoline); ingestion; intravenous; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation to eyes, skin, mucous membrane, and upper respiratory tract; abdominal pain; dizziness; cough; redness of skin; weakness; vomiting; diarrhea; lowering of consciousness; Chronic Risks: liver and kidney effects in animals.

**HAZARD RISK:** Extreme fire hazard when exposed to heat or flame; vapor may cause flash fire; forms explosive vapor/air mixtures; vapor is heavier than air and may travel along the ground, then flash back; distant ignition is possible; stable under normal conditions; decomposition emits acrid smoke and irritating fumes; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** S3; C&Sf; Sf3; T799-5000.

**MAJOR USES:** Octane booster in unleaded gasoline.

**STORAGE:** Keep in a tightly close container in a cool, dry, well-ventilated area away from heat, strong oxidizers, strong acids, sparks and open flames.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 40 ppm; Short Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) not established; IDLH not determined.

**PERSONAL PROTECTION:** Wear chemical-resistant gloves and clean body-covering clothing; use chemical safety goggles and/or a full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; use non-sparking type tools and equipment, including explosion proof ventilation; wear positive-pressure, air-supplied respirator; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Ventilate area of leak or spills; collect liquid in sealable containers or absorb with noncombustible materials (e.g., dry earth, sand, or vermiculite), and place in chemical waste container; use water spray to disperse vapors, and to flush spills away from exposures; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates respiratory tract, lightheadedness, dizziness, headache, weakness, nausea, central nervous system effects); skin (mild irritation, loss of natural oils); eyes (damage to eye tissue); ingestion (nausea, vomiting, affects laryngeal, ocular, and respiratory muscles).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 4g/kg; First aid: immediately rinse eyes with water; if inhaled remove to fresh air; if ingested was out mouth with water as long as victim is conscious.

**KEY REFERENCES:** 5; 6; 13; 14; 16.

#### **4,4'-METHYLENE BIS(2-CHLOROANILINE) (C<sub>13</sub>H<sub>14</sub>N<sub>2</sub>Cl<sub>2</sub>, 267.17)**

**CAS/DOT #:** 101-14-4/UN not available

**SYNONYMS:** Benzeneamine, bisamine, methylene-bis-ortho-chloroaniline.

**PHYSICAL PROPERTIES:** Colorless solid; used as yellow, tan or brown pellets; faint amine-like odor; soluble in hot methyl ethyl ketone, acetone, esters and aromatic hydrocarbons; MP (99-107°C, 210-225°F); DN (1.44 g/mL at 25°C); VP (1E-05 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Reacts vigorously with chemically active metals such as potassium, sodium, magnesium and zinc; FP (not available); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Occupational exposure; general public unlikely to be exposed.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: burning of face and eyes; gastrointestinal effects; nausea; kidney irritation; cyanosis; hematuria (blood in the urine); methemoglobinemia; Chronic Risks: effects on liver, blood and kidneys; tumors in animals.

**HAZARD RISK:** Decomposition emits toxic fumes of chlorine gas and nitrogen oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; U158; R4; R7; R8; A1.

**MAJOR USES:** Used in the production of epoxy resins, polyurethane, shoe soles, rolls for postage stamp machines, plywood, computers and pulleys for escalators and elevators.

**STORAGE:** Keep away from heat and flames.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.02 ppm; OSHA PEL none; NIOSH REL TWA 0.003 mg/m<sup>3</sup> (skin), potential occupational carcinogen; IDLH not determined, potential occupational carcinogen.

**PERSONAL PROTECTION:** Wear full protective garments, including rubber or plastic gloves; wear chemical safety goggles and/or full face shield; enclose operations and use local exhaust ventilation at site of chemical release; use self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Cover spill with absorbent; scoop into container; clean up residue with 1, 1, 1 - Trichloroethane.

**HEALTH SYMPTOMS:** Inhalation (tightness of chest, difficult breathing, cough, dry throat, wheezing, irritates eyes, skin and respiratory system); skin (skin blisters, burning of face); eyes (burning sensation); ingestion (gastrointestinal distress, blood in urine, nausea, irritation of kidneys).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2100 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash skin with large amounts of water and soap; if inhaled remove to fresh air.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 16.

**METHYLENE CHLORIDE (CH<sub>2</sub>Cl, 84.93)****CAS/DOT #:** 75-09-2/UN1593**SYNONYMS:** Dichloromethane, methylene dichloride, methylene bichloride.**PHYSICAL PROPERTIES:** Clear, colorless liquid; slightly sweet odor; slightly soluble in water; miscible with polar organic solvents; MP (-97°C, -142°F); BP (40°C, 104°F); LSG (1.33); VD (2.93); VP (350 mm Hg at 20°C); ST (26.52 dynes/cm); VS (0.430 cP at 20°C); OT (250 ppm).**CHEMICAL PROPERTIES:** Nonflammable; very stable; will not polymerize; reacts violently with alkali metals, strong oxidizers, caustics, magnesium powder, concentrated nitric acid, aluminum and potassium-tert-butoxide; FP (not available); AT (1033°F); LFL (13%); UFL (23%).**EXPOSURE ROUTES:** Inhalation (aerosol); ingestion (contaminated drinking water); absorption; occupational exposure.**HUMAN HEALTH RISKS:** Inhalation human LDLo 500 ppm for 8 hours; EPA Cancer Risk Level 2E-03 mg/m<sup>3</sup>; Acute Risks: irritation of eyes, skin, mucous membranes and respiratory tract; headaches; nausea; dizziness; fatigue; weakness; numb tingle in limbs; somnolence; Chronic Risks: paresthesia; altered sleep time; euphoria; convulsions; carcinogen.**HAZARD RISK:** Slight fire hazard; may explode in confined space; decomposition emits carbon monoxide, carbon dioxide, hydrogen chloride gas and phosgene gas; NFPA Code: H 2; F 1; R 0.**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.**APPLICABLE REGULATIONS:** CAA; S1; S10; C&Sf; Sfl; FIFRA; R2; R3; R4; R5; R7; R8; R9; T120-a; A1; A2.**MAJOR USES:** Used in the production of pharmaceuticals, paint and plastics; solvent; propellant; refrigerant; degreening agent in citrus fruit.**STORAGE:** Keep in a cool, dry, well-ventilated area away from active metals and food.**FIRE FIGHTING:** Use extinguishing media appropriate to surrounding fire conditions; all extinguishing media allowed; use water spray to cool exposed containers.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50ppm; OSHA PEL TWA 25 ppm; OSHA PEL STEL 125 ppm; NIOSH REL reduce to lowest feasible level; IDLH 2300ppm.**PERSONAL PROTECTION:** wear full protective clothing; rubber clothing may be used; wear chemical protective boots and chemical-resistant gloves; wear safety goggles and a self-contained breathing apparatus approved for organic vapors and fumes; use only in chemical fume hood.**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; flush remaining methylene chloride with large amounts of water and disperse, but not into confined spaces such as sewers because of danger of explosion.

**HEALTH SYMPTOMS:** inhalation (anesthetic effects, nausea, an drunkenness); contact (skin irritation, irritation of eyes and nose).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1600 mg/kg; First aid: wash eyes and skin with large amounts of water; if inhaled remove to fresh air; if ingested wash out mouth.

**KEY REFERENCES:** 1; 2; 4; 5; 6; 7; 9; 10; 12; 13; 14; 16.

### **METHYLENE DIPHENYL DIISOCYANATE (C<sub>15</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub>, 250.26)**

**CAS/DOT #:** 101-68-8/UN2489

**SYNONYMS:** 4,4'-Diphenylmethanediisocyanate, MDI, methylene bisphenyl isocyanate.

**PHYSICAL PROPERTIES:** White to light yellow crystals or flakes; odorless; insoluble in water at 20°C; MP (37.2°C, 99°F); BP (172°C, 342°F); LSG (1.2); DN (1198 kg/m<sup>3</sup> at 20°C).

**CHEMICAL PROPERTIES:** Hazardous polymerization will occur; incompatible with amines, alcohol and acids; reacts with water to form insoluble polyureas; FP (218°C); AT (240°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TClO 130 ppb for 30 minutes; Acute Risks: tearing; wheezing; dermatitis; eczema; shortness of breath; burning sensation; headache; nausea; vomiting; destruction of tissues of mucous membranes, respiratory tract, eyes and skin; corneal damage; pulmonary secretions; respiratory sensitization; cough; Chronic Risks: dyspnea; skin sensitization; asthma; respiratory distress; probable carcinogen.

**HAZARD RISK:** Container explosion may occur with exposure to heat or flame; emits toxic fumes under fire conditions; decomposition emits carbon monoxide, carbon dioxide, hydrogen cyanide and nitrogen oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Bubbler; acetylate; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** A1.

**MAJOR USES:** Used in the production of polyurethanes and plastics.

**STORAGE:** Keep in a cool, dry area; keep in the dark; store away from incompatible chemicals, food and feedstuffs.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.005 ppm; OSHA PEL CL 0.2 mg/m<sup>3</sup>(0.02 ppm); NIOSH REL TWA 0.05 mg/m<sup>3</sup> (0.005 ppm); NIOSH REL CL 0.2 mg/m<sup>3</sup>/10M (0.020 ppm); IDLH 75 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear clean waterproof protective clothing (coveralls, rubber boots, cap sleeves, etc.); clean rubber gloves are recommended; wear chemicals safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber equipped with effluent gas cleaning device; sweep up, place in a bag, and hold for waste disposal; avoid raising dust.

**HEALTH SYMPTOMS:** inhalation (dyspnea, coughing, chest pain, wheezing, reduced pulmonary function, headache, nausea, vomiting, asthma, laryngitis, irritates eyes, nose and throat); contact (dermatitis, eczema).

**GENERAL COMMENTS:** First aid: immediately wash eyes with water or saline for 20 minutes; if skin contact occurs immediately remove clothing and wash with water; if inhaled remove to fresh air; if ingested give 1 or 2 glasses of water and do not induce vomiting; in all cases, immediately seek medical assistance.

**KEY REFERENCES:** 4; 11; 12; 14; 16.

#### **4,4'-METHYLENEDIANILINE (C<sub>13</sub>H<sub>14</sub>N<sub>2</sub>, 198.29)**

**CAS/DOT #:** 101-77-9/UN2651

**SYNONYMS:** 4-(4-Aminobenzyl) aniline, 4,4'-diaminodiphenylmethane, MDA.

**PHYSICAL PROPERTIES:** Pale yellow crystals; darkens when exposed to air; faint amine-like odor; slightly soluble in water; very soluble in alcohol, benzene and ether; MP (93°C, 199°F); BP (232°C, 450°F); VP (10 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Combustible; weak base; incompatible with strong oxidizers; hazardous polymerization will not occur; FP (440°F).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated bread); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Oral man TDLo 8420 g/kg; IARC Group 2B possible human carcinogen; Acute Risks: irritation of eyes and skin; dry skin; redness; cough; vomiting; fever; chills; jaundice; abdominal pain; weakness; anorexia; liver damage; hepatitis; myocardial damage; Chronic Risks: dermatitis; skin sensitization; effects on eyes, liver and spleen; tumors in animals.

**HAZARD RISK:** Combustible when exposed to heat or flame; decomposition emits toxic fumes of carbon dioxide, carbon monoxide, aniline and nitrogen oxides; NFPA Code: H 3; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter; reagent; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf3; CAL.

**MAJOR USES:** Used in the production of polyurethane foams, dyes, isocyanate resins, polyamides, rubber and elastomeric fibers; antioxidant for lubricating oils; corrosion preventative; curing agent.

**STORAGE:** Keep away from oxidizing materials.

**FIRE FIGHTING:** Use water spray, carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (0.81 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 0.010 ppm; OSHA PEL STEL 0.100 ppm; NIOSH REL TWA potential occupational carcinogen; IDLH not determined.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; a system of local exhaust ventilation (not if powder) is recommended to control emissions at the source and to prevent dispersion into the general work area; use self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable containers; carefully collect remainder, then remove to a safe place.

**HEALTH SYMPTOMS:** Inhalation (abdominal pain, nausea, vomiting, cough, fever, chills); skin contact (dry skin, redness, skin sensitization, dermatitis); ingestion (rigidity, jaundice, damage to the liver).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 347 mg/kg; First aid immediately wash eyes with large amounts of water; if skin contact occurs remove clothes and wash with water; if inhaled remove to fresh air and provide respiratory apparatus if needed; if ingested induce vomiting.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 13; 14; 16.

## **NAPHTHALENE** (C<sub>10</sub>H<sub>8</sub>, 128.18)

**CAS/DOT #:** 91-20-3/UN1334

**SYNONYMS:** Albocarbon, camphor tar, moth flakes, tar camphor, white tar.

**PHYSICAL PROPERTIES:** White volatile flakes or powder; mothball odor; slightly soluble in water; miscible with phenols, ethers and organic solvents; BP (218°C, 424°F); MP (80°C, 176°F); LSG (1.14); DN (1.175 g/mL at 25°C); ST (31.8 dynes/cm at 100°C); HC (159.3 J/mol-K at 15.5°C); VP (0.01 kPa at 25°C); OT (6.80 ppm).

**CHEMICAL PROPERTIES:** Combustible; sublimates at room temperature; reacts vigorously with oxidizers and chromic anhydride; FP (174°F); AT (525°C); LFL (0.9%); UFL (5.9%).

**EXPOSURE ROUTES:** Inhalation (mothballs and combustion of coal and oil); ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of skin, eyes and upper respiratory tract; vomiting; headache; listlessness; cyanosis; dark urine; profuse perspiration; malaise; renal

shutdown; optical neuritis; corneal injury; hemolytic anemia; hemoglobinuria; coma; Chronic Risks: cataracts; skin allergy; effects on eyes, blood, kidneys and lungs.

**HAZARD RISK:** Combustible but moderately difficult to ignite; volatilizes at room temperature; explosive vapor/air mixtures above flash point; reacts violently with chromic anhydride; NFPA Code: H 2; F 2; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S3; S40-j; C&Sf; Sfl; Sf3; U165; R3; R4; R5; R8; R9; CWA; CW1; CW2; CW3; CW4; CW5; T120-a; A1; CAL.

**MAJOR USES:** Used in the production of phthalic acids, naphthols, sulfonic acid, resins, lampblack, smokeless powder, anthraquinone, salicylic acid, perylene, insecticides and moth repellent; toilet bowl deodorant; medication.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from oxidizers; may be stored under nitrogen gas.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide, water spray or appropriate foam; direct contact with water causes naphthalene to splatter.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm; ACGIH TLV STEL 15 ppm; OSHA PEL TWA 10ppm (50mg/m<sup>3</sup>); OSHA PEL STEL 15 ppm; NIOSH REL TWA 10ppm (50mg/m<sup>3</sup>); NIOSH REL STEL 15 ppm (75 mg/m<sup>3</sup>); IDLH 250ppm.

**PERSONAL PROTECTION:** Wear coveralls, rubber apron, rubber shoes or boots; wear chemical-resistant rubber gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** Ventilate area of spill; shovel small quantities into suitable dry container and burn in a safe place (such as a fume hood); remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes, nose and throat, headaches, dizziness, nausea); skin absorption (severe eye irritation, injuries to the cornea, cataracts, optical neuritis); ingestion (hemolytic anemia, hemoglobinuria).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 490 mg/kg; First aid: wash eyes and skin with water; remove to fresh air; if ingested wash mouth; call physician.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 13; 14; 16.

### **NICKEL COMPOUNDS (NiX, MW of Ni 58.71, formula weight varies by compound)**

**CAS/DOT #:** Ni: 7440-02-0 (varies by compound)

**SYNONYMS:** Ni: Alnico; Nickel Sulfate: nickel monosulfate, nickelous sulfate, nickel(II) salt.

**PHYSICAL PROPERTIES:** Ni: malleable, silver-white metal; insoluble in water; MP (1455°C, 2651°F); BP (2730°C, 4946°F); DN (8.90 g/mL at 20°C); VP (1 mm Hg at 1810°C);

Nickel Sulfate: greenish yellow solid; odorless; soluble in water; insoluble in ether and acetone; MP (840°C, 1544°F); LSG (3.68); Nickel carbonyl: colorless to brownish liquid; musty odor; insoluble in water; MP (-25°C, 13°F); BP (43°C, 109°F); LSG (1.32).

**CHEMICAL PROPERTIES:** Nickel sulfate: not flammable; Nickel Carbonyl: FP (<4°F); AT (140°F); LFL (2%); UFL (34%); oxidizes in air; decomposes explosively at 140°F; reacts with nitric acid, halogens and oxidizing materials.

**EXPOSURE ROUTES:** Inhalation (emissions from burning fuels); ingestion; adsorption; occupational exposure (electroplating, smelting and welding industries).

**HUMAN HEALTH RISKS:** EPA Group A human carcinogen (nickel refinery dust, nickel subsulfide); EPA Group B2 probable human carcinogen (nickel carbonyl); Acute Risks: Nickel Carbonyl: irritation of throat and airways; headache; irritability; vomiting; chest pains; skin allergy; insomnia; lung damage; vertigo; sweating; cyanosis; severe weakness; Chronic Risks: Nickel Carbonyl: lung and nasal sinus cancer; damage to heart, liver and kidneys; skin allergy; Nickel Sulfate: mutations; lung allergy; wheezing; infertility in males.

**HAZARD RISK:** Flammable; explosion hazard; poisonous gases produced under fire conditions; vapors may travel to a source of ignition and flash back; NFPA Code: not available.

**MEASUREMENT METHODS:** Particulate filter; acid; inductively coupled plasma.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sfl; CWA; CW3.

**MAJOR USES:** Used in the production of metal coins, jewelry, valves, heat exchangers, batteries, dyes, spark plugs, stainless steels and machinery parts; nickel plating; catalyst.

**STORAGE:** Keep in a tightly closed container in a cool, well-ventilated area away from strong acids and oxidizers.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide, water spray or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg(Ni)/m<sup>3</sup>; OSHA PEL TWA (insoluble compounds) 1 mg(Ni)/m<sup>3</sup>; NIOSH REL TWA (inorganic nickel) 0.015 mg(Ni)/m<sup>3</sup>; IDLH 10mg(Ni)/m<sup>3</sup>.

**PERSONAL PROTECTION:** Use laboratory protective equipment (lab coat, gloves, footwear, vent hood); use polyvinyl chloride, not rubber, for gloves; wear dust-proof goggles or face shield when working with powders or dusts; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** Shovel powdered material and deposit in sealed containers; liquid containing nickel should be absorbed in vermiculate, dry sand, earth, or a similar material; keep nickel powder out of a confined space, such as a sewer, because of the danger or explosion; remove all ignition sources.

**HEALTH SYMPTOMS:** Inhalation (chronic irritation of upper respiratory tract, loss of sense of smell, bronchial asthma, pulmonary fibrosis, pneumonconiosis, increase risk of nasal and lung cancer); ingestion (vomiting, diarrhea, nausea, headache, giddiness, lassitude, tremor, respiratory problems, death); contact (dermatitis, eczema).

**GENERAL COMMENTS:** First aid: water rinse.

**KEY REFERENCES:** 1; 4; 5; 6; 7; 10; 13; 14; 16.

**NITROBENZENE (C<sub>6</sub>H<sub>5</sub>NO<sub>2</sub>, 123.12)**

**CAS/DOT #:** 98-95-3/UN1662

**SYNONYMS:** Essence of mirbane, mirbane oil, nitrobenzol, oil of mirbane.

**PHYSICAL PROPERTIES:** Greenish-yellow crystals or yellow, oily liquid; pasty shoe polish odor; soluble in water, alcohol, benzene, ether, oils and acetate; MP (5-6°C, 41-43°F); BP (210°C, 410°F); DN (1.203 g/mL at 20°C); VD (4.3); VP (0.04 kPa at 25°C); ST (43.9 dynes/cm at 20°C); HV (55.01 kJ/mol at 25°C); OT (1.46E-02 mg/L).

**CHEMICAL PROPERTIES:** Combustible; sublimes at room temperature; incompatible with strong oxidizers, reducers, bases, concentrated nitric acid, nitrogen tetroxide, phosphorous pentachloride, caustics and active metals; AT (899°F); FP (190°F); LFL (1.8%); UFL (40.0%).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin, mucous membranes and upper respiratory tract; cyanosis; anoxia; anemia; methemoglobinuria; lowering of consciousness; CNS effects; death; Chronic Risks: effects on blood, blood forming organs, CNS, male reproductive system, liver and spleen.

**HAZARD RISK:** Combustible liquid; moderate fire and explosion hazard; forms explosive vapor/air mixtures; emits toxic fumes including nitrogen oxides under fire conditions; NFPA Code: H 3; F 2; R 1.

**MEASUREMENT METHODS:** Silica gel; methanol; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S3; S10; R3; R4; R5; RR6; R8; D036; U169; C&Sf; Sf1; Sf2; Sf3; CWA; CW1; CW2; CW4; CW5; T120-a; A1; CAL.

**MAJOR USES:** Used in the production of soaps, polishes, aniline, cellulose ethers, cellulose acetate, pesticides, dyes, pesticides, pharmaceuticals, spray paints and perfumes; almond essence substitute.

**STORAGE:** Keep in a cool, dry, dark, well-ventilated area away from oxidizers, acids, combustible substances, bases and metals.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide, water spray or appropriate foam; use water to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm (skin); OSHA PEL TWA 1ppm (5mg/m<sup>3</sup>)(skin); NIOSH REL TWA 1ppm (5mg/m<sup>3</sup>)(skin); IDLH 200ppm.

**PERSONAL PROTECTION:** Wear chemical protective suit with self-contained breathing apparatus; wear chemical resistant rubber gloves; wear splash-proof safety goggles; an eyewash fountain and safety shower are recommended.

**SPILL CLEAN-UP:** Ventilate area of spill or leak; use appropriate foam to blanket release and suppress vapors; absorb small quantities of liquid on paper towels and evaporate in fume hood; allow solid form to melt and cover in noncombustible material for proper disposal; atomize large amounts in a suitable combustion chamber equipped with an effluent gas cleaning device; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates skin, eyes, and respiratory system); skin absorption (methemoglobinemia, cyanosis); ingestion (general anesthetic, respiratory stimulation, vascular changes).

**GENERAL COMMENTS:** First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash with water; if inhaled remove to fresh air; if ingested wash mouth if conscious and call a physician.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 13; 14; 16.

#### **4-NITROBIPHENYL (C<sub>12</sub>H<sub>9</sub>NO<sub>2</sub>, 199.22)**

**CAS/DOT #:** 92-93-3/UN not available

**SYNONYMS:** p-nitrobiphenyl, 4-nitrodiphenyl, p-phenylnitrobenzene, PNB.

**PHYSICAL PROPERTIES:** White to light yellow to reddish crystalline solid or liquid; sweet odor; insoluble in water; miscible with organic liquids; MP (112-114°C, 234-237°F); BP (340°C, 644°F); DN (1.203 g/mL at 20°C).

**CHEMICAL PROPERTIES:** Combustible solid; incompatible with strong reducers and oxidizers; FP (143°C); AT (180°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: headache; dizziness; lethargy; ataxia; weakness; urinary burning; acute hemorrhagic cystitis; Chronic Risks: effects on blood and bladder; tumors in animals.

**HAZARD RISK:** Fire hazard when exposed to heat or flame; decomposition emits toxic fumes of nitrogen oxides; NFPA Code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter/silica gel; 2-propanol; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf3; A1.

**MAJOR USES:** Used in the production of p-biphenyl amine, fungicides and wood preservative; not currently used, manufactured, imported, or sold in the United States.

**STORAGE:** Keep in tightly closed container.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV confirmed human carcinogen; OSHA PEL TWA cancer suspect agent (use 1910.1003); NIOSH REL TWA potential occupational carcinogen; IDLH (not determined) potential occupational carcinogen.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical resistant gloves, apron, elastic sleeves and disposable coveralls; wear dust-proof safety goggles, enclose operations above 143°C and/or use local exhaust ventilation at site of chemical release; wear any self-contained breathing apparatus that has a full facepiece and is operated in positive-pressure mode; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** Ventilate area of spill; cover spill with dry lime or soda ash, and deposit in sealable containers; wash remaining spill with plenty of water; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (headache, dizziness, shortness of breath); skin absorption (weakness, lethargic feeling, muscle incoordination); ingestion (urinary burning, formation of methemoglobin, hemorrhagic cystitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2230 mg/kg; First aid: immediately irrigate eyes with large quantities of water; if skin contact occurs remove clothing and wash immediately with large quantities of water and soap; if inhaled remove to fresh air and provide artificial respiration as needed; if ingested immediately seek medical attention.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 13; 14; 16.

#### **4-NITROPHENOL (C<sub>6</sub>H<sub>5</sub>NO<sub>3</sub>, 139.11)**

**CAS/DOT #:** 100-02-7/UN1663

**SYNONYMS:** 4-Hydroxynitrobenzene, niphen, nitrophenol, p-nitrophenol.

**PHYSICAL PROPERTIES:** Colorless to light yellow crystals; characteristic odor; sweet, burning taste; slightly soluble in cold water; miscible with alcohol, ether, chloroform, hydroxides and acarbonates; MP (115°C, 239°F); BP (279°C, 534°F); LSG (1.48); VP (7 mm Hg at 165°C).

**CHEMICAL PROPERTIES:** Combustible solid; hazardous polymerization will not occur; strong oxidant; incompatible with oxidizers, combustible substances, acid chlorides, acid anhydrides and strong bases; FP (169°C); AT (283°C); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute risks: irritation of eyes, skin and respiratory system; burning sensation; cough; dizziness; weakness; headache; drowsiness; metabolism increase; racing heart; thirst; sweating; fever; nausea; upset stomach; ringing in ears; collapse; cyanosis; Chronic Risks: cyanosis; mutagenic effects; effects on CNS and blood.

**HAZARD RISK:** Closed containers may explode when exposed to heat or flame; finely dispersed particles form explosive mixtures in air; forms explosive mixtures with diethyl phosphite and potassium hydroxide; exothermic decomposition emits toxic fumes of carbon monoxide, carbon dioxide and nitrogen oxides; NFPA Code: H 3; F 1; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; CWA; CW4; CW5; CAL.

**MAJOR USES:** Used in the production of parathion, dyes, pharmaceuticals and fungicide for leather.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from oxidizers and alkalis.

**FIRE FIGHTING:** Use dry chemical powder, appropriate foam, carbon dioxide or water spray; use water to keep exposed containers cool; fight fire from protected location or maximum possible distance.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV) not established; OSHA PEL none; NIOSH REL not established; IDLH not determined.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including rubber boots, heavy rubber gloves, lab coat, apron or coveralls; use chemical safety goggles and/or full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; self-contained breathing apparatus is required in oxygen-deficient atmospheres; maintain eye-wash baths and safety showers in work area.

**SPILL CLEAN-UP:** Ventilate area of leak or spill; sweep up and containerize for proper disposal; use vacuuming or wet sweeping to avoid dust dispersal.

**HEALTH SYMPTOMS:** Inhalation (irritates respiratory tract, coughing, shortness of breath); skin (redness, itching, pain, burns to skin tissue); eyes (irritation, redness, pain, burns); ingestion (blue lips, headaches, dizziness, collapse, upset stomach, weakness, confusion, thirst, sweating, rapid heartbeat, ringing in ears, fever).

**GENERAL COMMENTS:** First aid: immediately wash eyes with water for 15 minutes; if skin contact occurs remove clothing and wash with water for 15 minutes; if inhaled remove to fresh air and provide artificial respiration as needed; if ingested wash mouth with water if victim is conscious.

**KEY REFERENCES:** 3; 5; 6; 7; 10; 13; 14; 16.

## **2-NITROPROPANE (C<sub>3</sub>H<sub>7</sub>NO<sub>2</sub>, 89.11)**

**CAS/DOT #:** 79-46-9/UN2608

**SYNONYMS:** Carbamic chloride, dimethylnitromethane, iso-nitropropane, 2-NP.

**PHYSICAL PROPERTIES:** Colorless liquid; fruity odor; soluble in water; miscible with most organic liquids; MP (-93°C, -135°F); BP (120.3°C, 248.5°F); LSG (0.98); VP (20 mm Hg at 25°C); ST (30 dynes/cm); VD (3.06); HV (9.88 kcal/mol at 25°C); HF (-43.78 kcal/mol at 25°C); OT (24.9 ppm).

**CHEMICAL PROPERTIES:** Will not polymerize; incompatible with alkalis, amines, lead, copper and oxidizers; FP (82°F); AT (428°C); LFL (2.6%); UFL (11.0%); HC (477.6 kcal/mol at 25°C).

**EXPOSURE ROUTES:** Inhalation (indoor air and tobacco smoke); ingestion; occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation man TCl<sub>o</sub> 20 ppm; EPA Group 2B probable human carcinogen; Acute Risks: irritation of eyes, skin and respiratory tract; drowsiness; vomiting; headache; diarrhea; kidney damage; liver damage; Chronic Risks: methemoglobinemia; cyanosis; anoxia; severe headache; pulmonary irritation; liver effects; hypermotility.

**HAZARD RISK:** Very dangerous fire hazard; may explode on heating; may form explosive vapor/air mixtures; flashback along vapor trail may occur; ignites on contact with carbon/hopcalite mixtures; many reactions result in fire or explosion; NFPA Code: H 1; F 3; R 2.

**MEASUREMENT METHODS:** Chromosorb tube; ethyl acetate; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S10; R4; R7; U171; C&Sf; Sf1; Sf3; T30-e10; T120-d10; A1; CAL.

**MAJOR USES:** Used in the production of explosives, gasoline, paint remover, propellants, inks, rubber, dyes, resins, organic compounds, vinyl and epoxy coatings and pharmaceuticals.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from amines, acids, alkalis, oxidizers, metal oxides, combustibles; preferable outside or detached storage.

**FIRE FIGHTING:** Use dry chemical powder, foam or carbon dioxide; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm; OSHA PEL TWA 25ppm (90 mg/m<sup>3</sup>); NIOSH REL TWA reduce to lowest feasible level; IDLH 100ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; cover spills with soda ash and spray with water; neutralize with hydrochloric acid and pass into drain with sufficient amounts of water; remove all ignition sources.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, coughing, breathing difficulty, irritates eyes and skin); ingestion (nausea, vomiting).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 720 mg/kg; First aid: wash eyes and skin with water; induce vomiting.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 11; 13; 14; 16.

### **n-NITROSO-n-METHYLUREA (C<sub>2</sub>H<sub>5</sub>N<sub>3</sub>O<sub>2</sub>, 103.10)**

**CAS/DOT #:** 684-93-5

**SYNONYMS:** Methylnitrosourea, n-methyl-n-nitrosourea, nitrosomethylurea.

**PHYSICAL PROPERTIES:** Light yellow crystals; MP (124°C, 255°F).

**CHEMICAL PROPERTIES:** Decomposes at melting point.

**EXPOSURE ROUTES:** Primarily in chemical research laboratories.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: dermatitis; Chronic Risks: tumors in animals.

**HAZARD RISK:** Explodes at room temperature; can explode with potassium hydroxide and dichloromethane; decomposition emits toxic fumes of nitrogen oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; R4; R7; R8; U177; C&Sf; Sf1; Sf3; CAL.

**MAJOR USES:** Used primarily in laboratories: synthesis of diazomethane, cancer chemotherapy agent, mutagenic effects on plants and antitumoral drug.

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV none; OSHA PEL none; NIOSH REL none.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, butyl rubber gloves, lab coat, apron or coveralls; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; at any exposure level, wear a NIOSH-approved supplied air respirator with a full facepiece or us self-contained breathing apparatus operated in positive pressure mode; provide eyewash fountains and safety showers in work area.

**SPILL CLEAN-UP:** Dampen solid spill material with 5% acetic acid, then transfer to a suitable container; use absorbent paper dampened with 5% acetic acid to pick up any residue material; wash all contaminated surfaces with 5% acetic acid followed by washing with a soap and water solution.

**HEALTH SYMPTOMS:** Inhalation (wheezing, coughing, hoarseness, shortness of breath, burning in mouth, throat or chest); skin (redness, skin rashes); eyes (redness, irritation, damage to the retina); ingestion (headache, weakness, drowsiness, nausea, vomiting, diarrhea, epigastric pain, loss of appetite).

**GENERAL COMMENTS:** Oral rat TDLo 5 mg/kg; First aid: flush eyes with water or normal saline solution for several minutes; immediately wash all affected skin areas thoroughly with plenty of soap and water; administer oxygen if breathing is difficult; begin rescue breathing if breathing has stopped; in case of ingestion, give one or two glasses of water to dilute the chemical and transfer promptly to a medical facility.

**KEY REFERENCES:** 5; 6; 13; 14; 16.

**n-NITROSODIMETHYLAMINE (C<sub>2</sub>H<sub>6</sub>N<sub>2</sub>O, 74.10)**

**CAS/DOT #:** 62-75-9/UN not available

**SYNONYMS:** Dimethylnitrosamine, n,n-dimethylnitrosamine, DMNA, NDMA.

**PHYSICAL PROPERTIES:** Yellow, oily liquid; faint, characteristic odor; highly soluble in water, alcohol and ether; miscible with methylene chloride and vegetable oils; BP (153°C, 307°F); MP (not available); DN (1.0048 g/mL at 20°C); VP (2.7 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Combustible; stable at room temperature; UV-sensitive; photochemically reactive; incompatible with strong oxidizers.

**EXPOSURE ROUTES:** Inhalation (tobacco smoke and contaminated ambient air); ingestion (contaminated food, cured meats and smoked fish); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Oral woman LDLo 20 mg/kg for 2.5 years; EPA Group B2 probable human carcinogen; Acute Risks: headache; vomiting; liver damage; fever; abdominal cramps; decreased liver, kidney and pulmonary function; ulceration or bleeding in small intestine; jaundice; kidney effects; malaise; diarrhea; Chronic Risks: liver damage; swelling; jaundice; low platelet counts.

**HAZARD RISK:** Decomposition on heating emits toxic fumes of nitrogen oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Thermosorb tube; methanol/methylene chloride; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; R3; R4; R5; P082; C&Sf; Sf1; Sf2; Sf3; CWA; CW4; CW5; A1; CAL.

**MAJOR USES:** Used in the production of lubricants, plastics, rocket fuel, fibers, nematocide and rubber; antioxidant; increase dielectric constant; inhibition of nitrification in soil.

**STORAGE:** Keep in dark bottles.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA suspected human carcinogen; OSHA PEL [1910.1016] cancer suspect agent; NIOSH REL suspected occupational carcinogen; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including rubber boots, heavy rubber gloves, lab coat, rubber apron or coveralls; wear chemical safety goggles if splashing is possible; use adequate local exhaust ventilation to keep airborne concentrations below permissible exposure limits; wear self-contained breathing apparatus; maintain eyewash baths and safety showers in general work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; absorb spill with inert material (e.g., dry earth, sand, vermiculite), then place into a container; after absorbent has been picked up, surface should be thoroughly cleaned with strong detergent solution.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, nausea, vomiting, irritates eyes, skin, and upper respiratory tract); skin absorption (symptoms parallel those of inhalation); ingestion (abdominal cramps, nausea, vomiting, diarrhea, jaundice, gastrointestinal hemorrhage).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 37 mg/kg; First aid: immediately wash eyes with large amounts of water for 15 minutes following exposure; if skin contact occurs remove clothing and wash skin immediately with large amounts of water and soap.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 13; 14; 16.

**n-NITROSOMORPHOLINE (C<sub>4</sub>H<sub>8</sub>N<sub>2</sub>O<sub>2</sub>, 116.14)****CAS/DOT #:** 59-89-2**SYNONYMS:** Nitrosomorpholine, 4-nitrosomorpholine, NMOR.**PHYSICAL PROPERTIES:** Yellow crystals; soluble in water; MP (29°C, 84°F); BP (140°C, 284°F); DN (not available).**CHEMICAL PROPERTIES:** FP (not available); AT (not available); LFL (not available); UFL (not available).**EXPOSURE ROUTES:** Inhalation (air in cars), absorption (rubber-stoppered blood collection tubes), occupational exposure.**HUMAN HEALTH RISKS:** IARC Group 2B possible human carcinogen; Acute Risks: headache, nausea, loss of appetite, pulmonary edema, brain effects similar to those produced by the drug opium; Chronic Risks: tumors in animals, may damage the liver and kidneys.**HAZARD RISK:** Decomposition emits toxic fumes of nitrogen oxides; NFPA Code: not available.**MEASUREMENT METHODS:** Not available.**APPLICABLE REGULATIONS:** CAA; CA2; R4; R5; C&Sf; Sf3; CAL.**MAJOR USES:** Solvent for polyacrylonitrile; microbial agent; not used in the United States.**STORAGE:** Store in a refrigerator away from oxidizing materials; protect this material from exposure to light.**FIRE FIGHTING:** Control fires with a dry chemical, carbon dioxide, or Halon extinguisher.**EXPOSURE GUIDELINES:** ACGIH TLV none; OSHA PEL none; NIOSH REL none.**PERSONAL PROTECTION:** Wear Tyvek-type disposable protective clothing, including disposable Tyvek-type sleeves taped to gloves; enclose operations and use local exhaust ventilation at site of chemical release; at any exposure level, use a NIOSH approved supplied-air respirator with a full facepiece or self-contained breathing apparatus operated in positive pressure mode; provide eyewash baths and safety showers in work area.**SPILL CLEAN-UP:** Dampen solid spill with water, then transfer dampened material to a suitable container; pick up any remaining material with absorbent paper dampened with water; absorb liquids in dry earth, sand or vermiculite, and deposit in sealed containers; wash all contaminated surfaces with a soap and water solution; ventilate area after clean-up is complete; remove all sources of ignition.**HEALTH SYMPTOMS:** Inhalation (irritates nose, throat and lungs); eyes (burning sensation, seeing halos around lights); skin (burning sensation); ingestion (headache, nausea, abdominal cramps, loss of appetite, dangerous build-up of fluid in lungs, brain effects).**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 282 mg/kg; First aid: flush eyes with water or normal saline solution for several minutes; immediately wash all affected skin areas thoroughly

with plenty of soap and water; administer oxygen if breathing is difficult; begin rescue breathing if breathing has stopped; in case of ingestion, give one or two glasses of water to dilute the chemical and immediately call a physician.

**KEY REFERENCES:** 3; 5; 6; 10; 14; 16.

**PARATHION (C<sub>10</sub>H<sub>14</sub>NO<sub>5</sub>PS, 291.28)**

**CAS/DOT #:** 56-38-2/UN2783(liquid/dry), UN2784(flammable liquid)

**SYNONYMS:** Alkron, alleron, diethyl parathion, ethyl parathion, rhodiasol, vitrex.

**PHYSICAL PROPERTIES:** Pale yellow to brown liquid; garlic-like odor; almost insoluble in water; soluble in alcohols and organic solvents; MP (6°C, 43°F); BP (275°C, 527°F); DN (1.26 g/mL at 25°C); VP (3.78E-05 mm Hg at 20°C); VS (15.3cP at 25°C); ST (39.2 dynes/cm at 25°C); OT (0.47 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** Flammable; reacts with bases; incompatible with substances with pH > 7.5 and strong oxidizers; hydrolyzed quickly by alkalis; attacks some plastics, rubbers and coatings; FP (120°C); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; ingestion (contaminated food); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Oral human LD<sub>50</sub> 3 mg/kg; Acute Risks: headache; weakness; excessive salivation; abdominal cramps; vomiting; difficulty breathing; confusion; ataxia; wheezing; cardiac irregularity; sweating; rhinorrhea; cyanosis; vision problems; paralysis; respiratory failure; spasms; coma; death; Chronic Risks: depressed red blood cell cholinesterase activity; liver effects; headaches; depressed plasma; birth defects.

**HAZARD RISK:** Fire hazard when exposed to heat or flame; violent reaction with endrin; decomposition emits toxic fumes of carbon monoxide, nitrogen oxides, phosphorous oxides and sulfur oxides; vapor is heavier than air and may travel along the ground, then flash back; distant ignition is possible; NFPA Code: H 4; F1; R 0.

**MEASUREMENT METHODS:** Particulate filter; isooctane; gas chromatography with flame photometric detection for sulfur, nitrogen, or phosphorus.

**APPLICABLE REGULATIONS:** CAA; Ca2; FIFRA; R3; R4; R5; U089; C&Sf; Sf1; Sf2; Sf3; CWA; CW1; CW2; A1; CAL.

**MAJOR USES:** Insecticide on fruit, cotton, wheat, vegetables and nuts; acaricide.

**STORAGE:** Keep away from oxidants, heat and sparks in a fireproof container; keep locked up.

**FIRE FIGHTING:** Use dry chemical powder, water spray, foam or carbon dioxide; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.05 mg/m<sup>3</sup>(skin); IDLH 10mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing; wear rubber boots and chemical resistant gloves; wear splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb small spills using sand, clay or other inert absorbent material; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (vomiting, abdominal cramps, diarrhea, weakness, headache, dizziness, labored breath); contact (prickling of skin, severe eye irritation, impaired sight, narrowing of pupils); ingestion (general anesthetic, pulmonary effects, kidney and bladder effects, changes in level of cholinesterase).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2 mg/kg; First aid: wash with water; induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 13; 14; 16.

### **PENTACHLORONITROBENZENE (C<sub>6</sub>Cl<sub>5</sub>NO<sub>2</sub>, 295.32)**

**CAS/DOT #:** 82-68-8/UN not available

**SYNONYMS:** Benzene, brassicol, PCNB, quintozene, tetrachlor.

**PHYSICAL PROPERTIES:** Light yellow crystalline powder; musty odor; insoluble in water; soluble in benzene and chloroform; BP (328°C, 622°F); MP (140-146°C, 284-295°F); DN (1.718 g/mL at 25°C); VD (10.2); VP (0.013 mm Hg at 25°C)

**CHEMICAL PROPERTIES:** Very stable; will not polymerize; reacts vigorously with strong oxidizers, acids and bases; FP (not available); AT (not available); LFL(not available); UFL (not available).

**EXPOSURE ROUTES:** Ingestion (contaminated food); occupational exposure.

**HUMAN HEALTH RISKS:** Acute risks: irritation of skin, eyes, upper respiratory tract and mucous membranes; allergic respiratory and skin reactions; Chronic Risks: thyroid effects; possible carcinogen.

**HAZARD RISK:** Decomposition emits toxic fumes of nitrogen oxides, chloride gas and phosgene gas; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; R3; R4; R5; R7; R8; U185; C&Sf; Sf1; FIFRA; CAL.

**MAJOR USES:** Soil fungicide; seed disinfectant for peanuts.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm; OSHA PEL not established; NIOSH REL not established; IDLH not determined.

**PERSONAL PROTECTION:** Wear chemical resistant clothing, such as lab coat and/or rubber apron; impervious gloves are required; wear approved chemical safety goggles, full length faceshield, and appropriate NIOSH/MSHA approved respirator; maintain eyewash fountains and safety showers in work area.

**SPILL CLEAN-UP:** Shovel spilled material into sealable containers, a leaking bottle containing pentachloronitrobenzene solution may be placed in a plastic bag, followed by normal disposal procedures; liquid samples may be absorbed on vermiculite or sand.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes, skin, and upper respiratory tract); skin (allergic reactions).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1100 mg/kg; First aid: immediately wash eyes with large amounts of water for 15 minutes following exposure; if skin contact occurs remove clothing and wash with water; if inhaled remove to fresh air and provide respiratory support as needed; if ingested was out mouth with water as long as victim is conscious.

**KEY REFERENCES:** 1; 3; 6; 9; 12; 13; 14; 16.

### PENTACHLOROPHENOL (C<sub>6</sub>HCl<sub>5</sub>O, 266.32)

**CAS/DOT #:** 87-86-5/UN2020

**SYNONYMS:** PCP, penta, 2,3,4,5,6-pentachlorophenol.

**PHYSICAL PROPERTIES:** Colorless to white crystalline powder or solid in various forms; benzene-like odor; almost insoluble in water; soluble in ethyl ether, ethyl alcohol and benzene; MP (188-191°C, 370-376°F); BP (310°C, 590°F (decomposes)); DN (1.978 g/mL at 22°C); VP (0.00011 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Reacts with strong oxidizers, bases, alkalis, acid chlorides and acid anhydrides; FP (not applicable); AT (not applicable); LFL (not applicable); UFL (not applicable); HV (70.05 kJ/mole at 25°C).

**EXPOSURE ROUTES:** Inhalation (air in pressure treated log homes); ingestion (contaminated food/drinking water); absorption (pressure treated lumber); occupational exposure.

**HUMAN HEALTH RISKS:** Oral human LDLo 401 mg/kg; Acute Risks: irritation of skin, eyes, mucous membranes and upper respiratory tract; sneezing; cough; weakness; anorexia; sweating; dyspnea; headache; nausea; vomiting; high fever; chest pain; lung edema; dermatitis; convulsions; Chronic Risks: liver, CNS, lungs and kidney effects; carcinogen.

**HAZARD RISK:** Moderate fire and explosion hazard; violent reactions with water and strong oxidizers; decomposition emits toxic fumes of hydrogen chloride, dioxins and chlorinated phenols; NFPA Code: H 3; F 0; R 0.

**MEASUREMENT METHODS:** Particulate filter/bubbler; isooctane; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S1; R3; R4; R5; R6; R8; R9; D037; F027; C&Sf; Sf1; Sf3; CWA; CW1; CW2; CW3; CW4; CW5; A1; CAL.

**MAJOR USES:** Used in the production of insecticides, fungicides, algicides, herbicides and sodium pentachlorophenate; wood preservation.

**STORAGE:** Keep in a dry, cool, well-ventilated area away from acids, alkalis, oxidizers and organic materials.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.5mg/m<sup>3</sup>(skin); NIOSH REL TWA0.5mg/m<sup>3</sup>(skin); IDLH 2.5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** Wear chemical protective clothing and chemical-resistant rubber gloves; wear chemical safety goggles and self-contained breathing apparatus; use only in a chemical fume hood.

**SPILL CLEAN-UP:** Ventilate area of spill; shovel spilled material into suitable dry container; absorb liquid containing pentachlorophenol in noncombustible materials such as dry earth, sand or vermiculite.

**HEALTH SYMPTOMS:** Inhalation (irritates skin and mucous membranes, coughing, sneezing); ingestion (loss of appetite, respiratory difficulties, anesthesia, sweating, coma); contact (dermatitis, chemical skin burns, slight eye damage).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 27 mg/kg; First aid: wash eyes and skin with water; remove clothing; wash out mouth with water.

**KEY REFERENCES:** 1; 3; 4; 6; 9; 10; 11; 12; 13; 14; 16.

## PHENOL (C<sub>6</sub>H<sub>6</sub>O, 94.12)

**CAS/DOT #:** 108-95-2/UN1671(solid), UN2312(molten) UN2821(solutions)

**SYNONYMS:** Carboic acid, hydroxybenzene, oxybenzene, phenic acid.

**PHYSICAL PROPERTIES:** Colorless to light pink crystalline solid; strong, sweet odor; soluble in water and ethyl alcohol; miscible with acetone and ethyl ether; MP (41°C, 106°F); BP (182°C, 358°F); LSG (1.07); VD (3.24); ST (40.9 dynes/cm at 20°C); VP (0.357 mm Hg at 20°C); HC (127.4 J/mole-K at 25°C).

**CHEMICAL PROPERTIES:** Light sensitive; combustible; incompatible with strong oxidizers, calcium hypochlorite, aluminum chloride and acids; FP (79°C); AT (1319°F); LFL (1.8%); UFL (8.6%); HC (3035.5 kJ/mole at 25°C); HF (-165.1 kJ/mole at 25°C); HV (45.69 kJ/mole at 181.8°C).

**EXPOSURE ROUTES:** Inhalation (contaminated air and tobacco smoke), ingestion (fried chicken, mountain cheese and fish), absorption (pharmaceuticals); occupational exposure.

**HUMAN HEALTH RISKS:** Oral human LDLo 14 mg/kg; Acute Risks: irritation of skin, eyes and mucous membranes; weakness; spasms; weak pulse; reduced blood pressure; loss

of coordination; paralysis; respiratory arrest; cardiac depression; convulsions; coma; Chronic Risks: muscle pain; necrosis; swelling; effects on liver, kidney, respiratory, cardiovascular and central nervous systems.

**HAZARD RISK:** Combustible solid; explosive reactions with formaldehyde and peroxysulfuric acid; decomposition emits acrid smoke and fumes; NFPA Code: H 4; F 2; R 0.

**MEASUREMENT METHODS:** XAD tube; methanol; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** CAA; CA2; R3; R4; R5; R6; R9; U188; C&Sf; Sf1; Sf2; CWA; CW1; CW2; CW3; CW4; CW5; T120-a; A1; CAL.

**MAJOR USES:** Used in the production of resins, ear and nose drops, throat lozenges, mouthwashes, pharmaceuticals, dyes and organic compounds.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from oxidizers and acute fire hazards.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (skin); OSHA PEL TWA 5 ppm (19mg/m<sup>3</sup>)(skin); NIOSH REL TWA 5 ppm (19mg/m<sup>3</sup>)(skin); NIOSH REL CL 15.6 ppm (60 mg/m<sup>3</sup>/15M); IDLH 250 ppm.

**PERSONAL PROTECTION:** Wear boots, rubber apron, and chemical-resistant gloves; wear positive pressure self-contained breathing apparatus; wear chemical safety goggles.

**SPILL CLEAN-UP:** Approach release from upwind; flush spill with flooding quantities of water; neutralize with caustic acid solution and isolate for proper disposal; remove all sources of ignition.

**HEALTH SYMPTOMS:** Absorption (damage to kidneys, liver, pancreas, and spleen; edema of the lungs); ingestion (burning of mouth and throat, abdominal pain, corrosion of lips, mouth, throat, esophagus, and stomach; gangrene); contact (irritation of eyes, nose and throat; skin burns, dermatitis; ochronosis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 317 mg/kg; First aid: rinse eyes, skin and mouth with water.

**KEY REFERENCES:** 1; 3; 4; 6; 9; 10; 11; 12; 13; 14; 16.

### **p-PHENYLENEDIAMINE (C<sub>6</sub>H<sub>8</sub>N<sub>2</sub>, 108.16)**

**CAS/DOT #:** 106-50-3/UN1673

**SYNONYMS:** 4-Aminoaniline, 1,4-benzenediamine, p-diaminobenzene.

**PHYSICAL PROPERTIES:** White or slightly red crystals; darkens on exposure to air; slightly soluble in water; soluble in alcohol, chloroform and ether; MP (146°C, 295°F); BP (267°C, 513°F); VP (1 mm Hg at 21°C); VD (3.72).

**CHEMICAL PROPERTIES:** Combustible; affected by light; incompatible with strong oxidizers; hazardous polymerization will not occur; FP (155°C).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption (contact with hair dyes); occupational exposure in industries that manufacture and/or use p-phenylenediamine.

**HUMAN HEALTH RISKS:** Oral man TDLo 71 mg/kg; skin human 250 mg for 24 hours; Acute Risks: irritation of eyes and skin; severe dermatitis; tearing; asthma; gastritis; renal failure; vertigo; tremors; coma; Chronic Risks: eczematoid contact dermatitis; liver damage; tumor growth in rats.

**HAZARD RISK:** Combustible when exposed to heat or flame; reacts vigorously with oxidizing materials; decomposition emits acrid smoke and irritating fumes.

**MEASUREMENT METHODS:** Coated particulate filter; EDTA; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sfi; SF3; R3; R5; T120-a; T799-3300; A1; CAL.

**MAJOR USES:** Used in the production of dyes; photographic developing agent; vulcanization accelerator; antioxidant in rubber compounds; accelerator for synthetic fibers; laboratory reagent; photochemical measurements.

**STORAGE:** Keep in a container away from contact with oxidizing materials.

**FIRE FIGHTING:** Use water spray, carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.1 mg/m<sup>3</sup>(skin); IDLH 25 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** Wear impervious clothing, gloves, and eight-inch minimum face shields; use dust-and splash-proof safety goggles; wear self-contained breathing apparatus operated in a positive pressure mode.

**SPILL CLEAN-UP:** Ventilate area of spill; sweep small quantities onto paper or other suitable material, and place in an appropriate container and cautiously ignite in open areas; dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber equipped with appropriate effluent gas cleaning device.

**HEALTH SYMPTOMS:** Inhalation (irritates the larynx and pharynx); skin absorption (vertigo, anemia, gastritis, sensitization dermatitis, death).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 80 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus if needed; if ingested give milk or water and induce vomiting.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 13; 14; 16.

**PHOSGENE (COCl<sub>2</sub>, 98.91)****CAS/DOT #:** 75-44-5/UN1076**SYNONYMS:** Carbon oxychloride, carbonyl chloride, chloroformyl chloride.**PHYSICAL PROPERTIES:** Colorless, highly toxic gas; suffocating odor reminiscent of moldy hay; slightly soluble in water; soluble in benzene, toluene, chloroform and carbon tetrachloride; BP (8.2°C, 46.8°F); MP (-128°C, -198°F); DN (1.372 g/mL at 25°C); VD (3.41); VP (1215 mm Hg at 20°C); ST (34.6 mN/m); HC (57.7 J/mole-K (gas at 25°C)).**CHEMICAL PROPERTIES:** Incompatible with moisture, alkalis, ammonia, alcohols and copper; HV (6224.2 gcal/gmol).**EXPOSURE ROUTES:** Inhalation (industrial emissions, decomposition of chlorinated hydrocarbons and photo-oxidation of chloroethylenes); occupational exposure.**HUMAN HEALTH RISKS:** Inhalation human LC<sub>50</sub> 3200 mg/m<sup>3</sup>; inhalation human TCLo 25 ppm for 30 minutes; Acute Risks: irritation of eyes and skin; severe respiratory effects; choking; chest constriction; painful breathing; bloody sputum; pulmonary edema; pulmonary emphysema; Chronic Risks: not available.**HAZARD RISK:** Decomposition emits toxic and corrosive fumes of Cl<sub>2</sub>; NFPA Code: H 4; F 0; R 1.**MEASUREMENT METHODS:** Impinger; reagent; visible spectrophotometry.**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf2; Sf3; R3; P095; CWA; CW1; CW2; A1; CAL.**MAJOR USES:** Used in the production of dyes, isocyanate based polymers, carbonic acid esters, insecticides, acid chlorides and pharmaceuticals; metallurgy; used as a chemical warfare agent in World Wars I and II.**STORAGE:** Not available.**FIRE FIGHTING:** Not available.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; OSHA PEL TWA 0.1 ppm (0.4mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.4mg/m<sup>3</sup>); NIOSH REL CL 0.2 ppm.15M (0.8 mg/m<sup>3</sup>/15M); IDLH 2 ppm.**PERSONAL PROTECTION:** Wear rubberized outerwear when liquid phosgene is involved; wear chemical safety goggles and gastight suit; wear full face gas masks or self-contained breathing apparatus.**SPILL CLEAN-UP:** Allow gas spills to flow into a mixed solution of caustic soda and lime; keep in a fume hood, if possible; cover liquid spills with sodium bicarbonate, soda ash or lime; cautiously atomize mixture with spray water and transfer into large container of water; water will increase evaporation of spilled material.**HEALTH SYMPTOMS:** Inhalation (choking, chest constriction, coughing, painful breathing, and bloody sputum); contact (severe skin and eye burns).

**GENERAL COMMENTS:** First aid: wash eyes with large amounts of water; if skin contact occurs remove clothing and wash with large amounts of water; if inhaled provide respiratory support as needed; if swallowed do not induce vomiting.

**KEY REFERENCES:** 3; 4; 6; 7; 9; 10; 11; 12; 13; 14; 16.

### **PHOSPHINE (PH<sub>3</sub>, 34.00)**

**CAS/DOT #:** 7803-51-2/UN2199

**SYNONYMS:** Hydrogen phosphide, phosphorated hydrogen, phosphorus hydride.

**PHYSICAL PROPERTIES:** Colorless, flammable gas; odor of decaying fish or garlic; insoluble in water; slightly soluble in ethyl ether and ethyl alcohol; BP (-87.5°C, -125.5°F); MP (-133°C, -207.4°F); VD (1.17); LSG (0.76); VP(>760 mm Hg at 20°C); HC (37.1 J/mole-K at 25°C).

**CHEMICAL PROPERTIES:** Spontaneously flammable in air in presence of P<sub>2</sub>H<sub>4</sub>; reacts violently with oxygen and halogens; AT 100°C; LFL (1.6%); UFL (98% (estimated)); HV (14.6 kJ/mole at -87°C).

**EXPOSURE ROUTES:** Inhalation (contaminated air); ingestion (residue-contaminated food); occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human LCLo 1000 ppm; Acute Risks: headache; fatigue; dizziness; burning substernal pain; nausea; cough with fluorescent green sputum; labored breathing; gastrointestinal distress; pulmonary edema; tremors; Chronic Risks: inflammation of the nasal cavity and throat; weakness; jaundice; liver effects; dizziness; increased blood density; CNS effects.

**HAZARD RISK:** Extreme fire hazard by spontaneous chemical reaction; ignition or violent reaction with air, oxidants, silver nitrate and concentrated nitric acid; decomposition emits highly toxic fumes of phosphorus oxides; NFPA Code: H 4; F 4; R 2.

**MEASUREMENT METHODS:** Beaded carbon; peroxide/buffer; ion chromatography.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf2; Sf3; R3; R4; R6; R8; P096; A1; CAL.

**MAJOR USES:** Insecticide for grain fumigation, animal feeds and tobacco; rodenticide; doping agent for n-type semiconductors; polymerization inhibitor; condensation catalyst; synthesis of flame retardants for cotton fabrics.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.3 ppm; ACGIH TLV STEL 1 ppm; OSHA PEL TWA 0.3 ppm (0.4 mg/m<sup>3</sup>); OSHA PEL STEL 1 ppm; NIOSH REL TWA 0.3 ppm (0.4 mg/m<sup>3</sup>); NIOSH REL STEL 1 ppm (1 mg/m<sup>3</sup>); IDLH 50 ppm.

**PERSONAL PROTECTION:** Wear special protective clothing and chemical-resistant gloves; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** Ventilate area of leak to disperse gas; use water spray to cool and disperse vapors; if source of leak is a cylinder, remove leaking cylinder to a safe place in open air and allow cylinder to empty.

**HEALTH SYMPTOMS:** Inhalation (lung irritation, pulmonary edema, heart dilation, weakness, vertigo, convulsions, coma); contact (muscle pain, chills, chest tightness).

**GENERAL COMMENTS:** First aid: provide respiratory support as needed.

**KEY REFERENCES:** 2; 3; 4b; 6; 9; 10; 11; 12; 13; 14; 16.

### **PHOSPHORUS (P, 30.97 - red; P<sub>4</sub>, 123.88 - white/yellow)**

**CAS/DOT #:** 7723-14-0/UN1381(yellow), UN2447(white)

**SYNONYMS:** Amorphous phosphorus.

**PHYSICAL PROPERTIES:** Red: Reddish-brown powder; BP (280°C, 536°F); MP (590°C, 1094°F); VD (4.77); LSG (2.34); insoluble in organic solvents; White: Cubic, colorless crystals or yellow leaflets; waxy solid; BP (280°C, 536°F); MP (44.1°C, 111°F); LSG (1.88); VD (4.42); VP (1 mm Hg at 76.6°C); soluble in water; soluble in carbon disulfide; phosphorescent at room temperature.

**CHEMICAL PROPERTIES:** Red: AT (500°F); ignites at boiling point; reacts only at high temperatures; less reactive than white phosphorus; White: AT (86°F); spontaneously ignites in air; reacts with sulfur, halogens, metals, nitric acid, alkali hydroxides; incompatible with iodine, oil or turpentine and potassium chlorate.

**EXPOSURE ROUTES:** Not available.

**HUMAN HEALTH RISKS:** Acute Risks: Red: tissue destruction; spontaneous fractures; vomiting; sweating; cyanosis; cardiomyopathy; weight loss; White: severe burns; severe eye damage; bloody diarrhea; gastrointestinal problems; circulatory collapse; convulsions; coma; Chronic Risks: Red: stomach irritation; vomiting; diarrhea; White: bony necrosis.

**HAZARD RISK:** Red: Fire hazard when exposed to heat or oxidizers; explosion hazard; may explode on impact; decomposition emits toxic fumes of phosphorus oxides; White: extreme fire hazard; ignites spontaneously in moist air; decomposition emits toxic fumes of phosphorus oxides; NFPA Code: Not available.

**MEASUREMENT METHODS:** Tenax gas chromatography tube; xylene; gas chromatography with flame photometric detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf2; Sf3; CWA; CW1; CW2; CAL.

**MAJOR USES:** Red: pyrotechnics; safety matches; organic synthesis; White: rat poisons; smoke screens; gas analysis.

**STORAGE:** Red: store in a cool, dry place; White: keep under water, away from heat.

**FIRE FIGHTING:** Use water.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg/m<sup>3</sup>; OSHA PEL TWA 0.1 mg/m<sup>3</sup>; NIOSH REL TWA 0.1 mg/m<sup>3</sup>; IDLH 5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** Wear chemical protective clothing and self-contained breathing apparatus; wear chemical safety goggles or protective face shield; chemical-resistant gloves are recommended.

**SPILL CLEAN-UP:** Smother release with wet sand, clay, or ground limestone; shovel into suitable dry container; control runoff and isolate discharged material.

**HEALTH SYMPTOMS:** Inhalation (severe internal irritation, collapse, convulsions, dilation of pupils, retinal hemorrhage, congestion of blood vessels, photophobia with myosis); contact (severe burns); ingestion (gastrointestinal irritation, bloody diarrhea, liver damage, skin eruption, nausea, vomiting, sweating, cardiomyopathy, cyanosis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 3030 g/kg; Personal protection: wear self-contained breathing apparatus (SCBA), gloves, goggles and protective clothing; First aid: immediately wash eyes and skin with large amounts of water; remove to fresh air and provide respiratory apparatus as needed; drink water.

**KEY REFERENCES:** 3; 4; 5; 6; 11; 16.

### **PHTHALIC ANHYDRIDE (C<sub>8</sub>H<sub>4</sub>O<sub>5</sub>, 148.12)**

**CAS/DOT #:** 85-44-9/UN2214

**SYNONYMS:** 1,3-Dioxiphthalan, 1,3-isobenzofurandione, PAN, phthalandione.

**PHYSICAL PROPERTIES:** White, needle-like solid or clear, colorless liquid; choking odor; slightly soluble in water; soluble in alcohol and ether; MP (130.8°C, 267.4°F); BP (295°C, 563°F); DN (1.20 g/mL at 135°C); ST (35.5 dynes/cm); VP (5.14E-04 mm Hg at 25°C); OT (0.053 µL/L).

**CHEMICAL PROPERTIES:** Combustible; FP (305°F); AT (570°C); LFL (1.7%); UFL (10.4%).

**EXPOSURE ROUTES:** Inhalation (contaminated air and plastic products); occupational exposure; exposure from blood bags, plastic syringes and plastic tubing.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin and respiratory tract; sneezing; acute nose pain; abdominal pain; diarrhea; vomiting; bloody nasal discharge; Chronic Risks: conjunctivitis; bloody sputum; emphysema; bronchitis; CNS excitation; low blood pressure.

**HAZARD RISK:** Combustible when exposed to heat or flame; moderate explosion hazard in the form of dust when exposed to flame; ignition by electric sparks; may generate electrostatic sparks; explosion upon heat of mixtures with copper oxide or sodium nitrite; NFPA Code: H 3; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter; ammonium hydroxide; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** CAA; CA2; R3; R6; U190; C&Sf; Sf1; Sf3; A1; CAL.

**MAJOR USES:** Used in the production of phthalic compounds, primary amines, phthalan, thalidomide, xanthene, rhodamine, plasticizers in resins and dyes.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm; OSHA PEL TWA 2ppm (12 mg/m<sup>3</sup>); NIOSH REL TWA 1ppm (6mg/m<sup>3</sup>); IDLH 60mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** Wear coveralls or rubber apron, rubber shoes or boots; gauntlet-type leather or rubber gloves are recommended; wear chemical safety goggles or face shield; self-contained breathing apparatus is recommended in high vapor concentrations.

**SPILL CLEAN-UP:** Shovel small quantities into suitable dry container, and burn in a fume hood; dissolve large quantities in a flammable solvent, and atomize in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; absorb liquid containing phthalic anhydride in noncombustible materials such as dry earth or sand.

**HEALTH SYMPTOMS:** Inhalation (coughing, increased mucous secretion, sore throat, breathing difficulty, upper respiratory tract irritation); skin contact (acid burns, dermatitis, sensitization, severe thermal burns caused by liquid); ingestion (sore throat, vomiting, diarrhea, cramps, abdominal pain).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 4020 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothes and wash with water and soap; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested drink water.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 11; 13; 14; 16.

**POLYCHLORINATED BIPHENYLS (A class of organic chemical with the formula C<sub>12</sub>H<sub>10-n</sub>Cl<sub>n</sub> that contains 209 individual compounds, 257.6-326.4)**

**CAS/DOT #:** 1336-36-3/UN2315

**SYNONYMS:** Aroclor, chlorinated biphenyl, chlorinated diphenyl, PCBs, phenoclor.

**PHYSICAL PROPERTIES:** Colorless to yellow oily liquid, white to yellow crystals or yellow to black resin; mild odor; virtually insoluble in water; soluble in oils and organic solvents; MP (340-375°C, 644-707°F); BP (275-420°C, 527-788°F); CP (<1 mm Hg at 38°C); LSG (1.20-1.56).

**CHEMICAL PROPERTIES:** Inert; stable to conditions of hydrolysis and oxidation in industrial use.

**EXPOSURE ROUTES:** Inhalation (indoor air and incineration fumes); ingestion (contaminated water, fish and other contaminated food); absorption (wastewater and soil).

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: irritation of eyes, skin and respiratory tract; chloracne; effects on liver, kidneys and CNS; Chronic Risks: cough; chest tightness; gastrointestinal effects; weight loss; vomiting; liver effects; chloracne; cardiovascular effects; skin discoloration; fetal effects.

**HAZARD RISK:** Combustible when exposed to heat or flame; decomposition emits toxic fumes of Cl<sup>-</sup>; NFPA Code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** n/a

**APPLICABLE REGULATIONS:** CAA; CA2; S1; S24; S32; S50-a; S61; S62; C&Sf; Sfl; Sf3; R3; R4; R5; R7; R8; CWA; CW1; CW2; CW3; CW4; CAL.

**MAJOR USES:** Used in production of inks, adhesives, pesticides, electrical capacitors and transformers; enzyme inducers; fire retardants; lubricating additives.

**STORAGE:** Employ detached storage in a cool, dry, well-ventilated place; check often for leakage.

**FIRE FIGHTING:** Use extinguishing media suitable for surrounding fire.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg/m<sup>3</sup>(skin); ACGIH TLV STEL 2 mg/m<sup>3</sup>(skin); OSHA PEL TWA 1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.001 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear chemical protective clothing consisting of zippered coverall with attached hood and drawstring, elastic cuffs, gloves, and closure boots; it is recommended that outer coveralls should be made of chemically resistant materials such as Saranax-coated Tyvek or Viton-coated neoprene; gloves and boots should be made of neoprene, nitrile, butyl rubber or Viton; wear splash-proof safety goggles; a closed system of local exhaust ventilation is required to control emissions at the source and to prevent dispersion into general work area; a self contained breathing apparatus operated in positive pressure mode should be worn where a risk of exposure to airborne contaminants exists; for extra personal protection, air-purifying full face-piece respirators equipped with a high efficiency particulate air filter and organic vapor cartridge may be employed.

**SPILL CLEAN-UP:** Dry sand or earth should be spread on the leak, or spill area; bulk liquid may also be absorbed with fly ash or cement powder; cleanup of areas contaminated with soot should involve dry vacuuming of surfaces with a vacuum cleaning system equipped with a high efficiency particulate (HEPA) filter; after preliminary cleanup, wash surfaces with alkaline of nonionic synthetic detergents in water; clean nonporous electrical and mechanical equipment with organic solvents; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (pulmonary effects, injury to liver, irritates eyes, nose and throat); contact (acne-skin rash, dermatitis, hyper-pigmentation); ingestion (gastrointestinal disturbances, yellow jaundice, dark urine, fatigue).

**GENERAL COMMENTS:** First aid: immediately wash eyes with large amounts of water; if skin contact occurs immediately remove clothing and wash skin with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus if needed; if ingested give water and induce vomiting.

**KEY REFERENCES:** 5; 6; 7; 10; 11; 13; 14; 16.

**POLYCYCLIC ORGANIC MATTER** (Varies by compound; benzo(a)pyrene:  $C_{20}H_{12}$ , 252.3)

**CAS/DOT #:** Varies by compound; benzo(a)pyrene: 50-32-8

**SYNONYMS:** Benzo(a)pyrene: benzo[def]chrysene, 3,4-benzopyrene, B[a]P.

**PHYSICAL PROPERTIES:** Colorless, white, or light yellow-green solids; faint, pleasant odor; benzo(a)pyrene: slightly soluble in water, ethanol and methanol; soluble in benzene, toluene, xylene and ether; MP (179°C, 354 °F); BP (310-312°C, 540-544°F); LSG (1.351); VP (5.6E-09 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Not available.

**EXPOSURE ROUTES:** Inhalation (ambient air, cigarette smoke, vehicle emissions, asphalt roads and agricultural or municipal burning); ingestion (contaminated drinking water); absorption; occupational exposure (incinerators, coal, coal tar and hazardous waste sites)

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: no information available for humans; Chronic Risks: irritation of eyes; cataracts; dermatitis; photosensitization; increases in lung cancer.

**HAZARD RISK:** Decomposition emits acrid smoke and fumes.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sfl.

**MAJOR USES:** Used in the production of plastics, pesticides, asphalt, medicines and dyes; most polycyclic organic compounds have no commercial uses.

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV (phenanthrene, cyclohexane extractable fraction) 1030 mg/m<sup>3</sup>; ACGIH TLV (coal tar pitch volatiles-benzene soluble) 0.2 mg/m<sup>3</sup>; NIOSH REL (coal tar pitch volatiles, benzo(a)pyrene) 0.1 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** Wear protective suits (one-piece, close-fitting at ankles and wrists, and disposable), gloves, disposable plastic aprons, overshoes, and hair covering; when working with particulates or gases, carefully fitted masks or respirators are required; enclose operations and use local exhaust ventilation at site of chemical release.

**SPILL CLEAN-UP:** Use a high-efficiency particulate arrestor (HEPA) filter to minimize amount of carcinogen; immediately transfer used filters into plastic bags after removal; place waste liquids in properly labeled containers for disposal; the plastic bag should also be sealed and labeled.

**HEALTH SYMPTOMS:** Inhalation (cough, bronchitis); eyes (photosensitivity, irritation); skin (precancerous lesions, erythema, dermal burns, photosensitivity acne-form lesions); ingestion (leukoplakia).

**GENERAL COMMENTS:** First aid: not available.

**KEY REFERENCES:** 3; 5; 6; 13; 14; 16.

**1,3-PROPANE SULTONE (C<sub>3</sub>H<sub>6</sub>O<sub>3</sub>S, 122.15)**

**CAS/DOT #:** 1120-71-4

**SYNONYMS:** 3-Hydroxy-1-propanesulphonic acid sultone, propane sultone.

**PHYSICAL PROPERTIES:** White, crystalline solid or colorless to light brown liquid (above 88°C); foul odor; soluble in water and organic solvents; MP (31°C, 88°F); BP (180°C, 356°F); DN (1.392 g/mL at 25°C).

**CHEMICAL PROPERTIES:** Combustible; volatile (sublimes readily); reacts vigorously with strong oxidizers, strong bases and strong acids; noncorrosive; FP (109°C).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption through skin and eyes; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: allergic skin reaction; tissue destruction in mucous membranes, upper respiratory tract, eyes and skin; Chronic Risks: alters genetic material; bone marrow disorders; damage to peripheral and central nervous systems.

**HAZARD RISK:** Combustible; fire hazard; NFPA Code: H 2; F 2; R 3.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; U193; C&Sf; Sf1; Sf3.

**MAJOR USES:** Used in the production of fungicides, insecticides, cation-exchange resins, dyes; vulcanization accelerator; introduction of sulfoxopropyl groups into molecules.

**STORAGE:** Keep in a tightly closed container in a cool, dry place; moisture sensitive.

**FIRE FIGHTING:** Use dry chemical powder, appropriate foam, carbon dioxide or water spray.

**EXPOSURE GUIDELINES:** ACGIH TLV not established; OSHA PEL not established; NIOSH REL reduce to lowest possible level, potential occupational carcinogen; IDLH not determined, potential occupational carcinogen.

**PERSONAL PROTECTION:** Wear protective gloves and clothing; wear splash-proof chemical goggles when working with liquid, dust-proof goggles when working with powders or dust; use a NIOSH-approved supplied air respirator with full facepiece or self-contained breathing apparatus operated in positive pressure mode; provide eyewash baths and safety showers in work area; enclose operations and/or use local exhaust ventilation at site of chemical release.

**SPILL CLEAN-UP:** Collect powdered material in convenient and safe manner (e.g., vacuuming, using a high efficiency particulate absolute (HEPA) filter); absorb liquids in dry earth, sand or vermiculite, and deposit in sealed containers.

**HEALTH SYMPTOMS:** Inhalation (irritates nose and throat); skin (skin burns, irritates mucous membranes).

**GENERAL COMMENTS:** Oral rat LDLo 7840 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash skin immediately with water; if inhaled remove to fresh air and provide respiratory support as needed.

**KEY REFERENCES:** 4; 5; 6; 10; 11; 14; 16.

**beta-PROPIOLACTONE (C<sub>3</sub>H<sub>4</sub>O<sub>2</sub>, 72.07)**

**CAS/DOT #:** 57-57-8

**SYNONYMS:** Betaprone, BPL, 3-hydroxy-propionic acid, beta-lactone, 3-propiolactone.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; slightly sweet odor; highly soluble in water; MP (-33°C, -27°F); BP (155°C, 311°F); LSG (1.1460); VP (3.4 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Combustible; incompatible with strong oxidizers, acetates, halogens, thiocyanates and bases; reacts with alcohol; stable when stored in glass in refrigerator; FP (75°C); LFL (2.9%); UFL (not available).

**EXPOSURE ROUTES:** Inhalation; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: severe irritation of eyes, skin and respiratory tract; skin burns and blisters; permanent corneal opacification; spasms; breathing difficulty; mouth and stomach burns; liver and kidney damage; death; Chronic Risks: skin irritation; tumors in animals.

**HAZARD RISK:** Combustible; decomposition emits acrid smoke and fumes of carbon dioxide and carbon monoxide; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf3; A1; CAL.

**MAJOR USES:** Used in vaccines, tissue grafts, enzymes and surgical instruments; sterilize blood plasma, water, milk and nutrient broth; used against viruses.

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV 0.5 ppm (1.5 mg/m<sup>3</sup>) suspected human carcinogen; OSHA PEL (1910.1013) carcinogen; NIOSH REL potential occupational carcinogen; IDLH (not determined) potential occupational carcinogen.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles or face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; collect spilled liquid in sealable containers or absorb in sand or inert absorbent; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (cough, headache, shortness of breath, burning sensation, nausea, vomiting, irritates eyes, skin, and respiratory system); skin contact (burns of the skin, blisters); eye contact (severe deep burns, redness, pain) ingestion (burning sensation, sore throat, nausea, vomiting).

**GENERAL COMMENTS:** Oral rat TDLo 2868 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and flush skin with large amounts of water and soap; if inhaled remove to fresh air immediately.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 13; 14; 16.

### **PROPIONALDEHYDE (C<sub>3</sub>H<sub>6</sub>O, 58.09)**

**CAS/DOT #:** 123-38-6/UN1275

**SYNONYMS:** Propanal, propionic aldehyde, propyl-aldehyde.

**PHYSICAL PROPERTIES:** Colorless liquid; fruity, suffocating odor; coffee, cocoa taste; soluble in water, alcohol and ether; MP (-81°C, -114°F); BP (48°C, 120°F); DN (0.8071 g/mL at 20°C); ST (23.4 dynes/cm); VS (0.47 cP at 760 mm Hg); VD (2.0).

**CHEMICAL PROPERTIES:** Polymerization may occur; reacts with oxidizers, amines, alkalis and acids; FP (15-19°F); AT (405°F); HV (211 Btu/lb); LFL (2.6%); UFL (16.1%).

**EXPOSURE ROUTES:** Inhalation (ambient air, municipal waste incineration emissions, combustion products of wood, gasoline, diesel fuel and tobacco smoke); ingestion (contaminated drinking water and coffee); occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin and respiratory tract; vomiting; narcosis; loss of consciousness; Chronic Risks: no information available for humans.

**HAZARD RISK:** Dangerous fire hazard when exposed to heat or flame; vigorous polymerization with methyl methacrylate; vapors heavier than air and may flash back from ignition source; closed containers may explode when heated; NFPA Code: H 2; F 3; R 2.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sfl; CAL.

**MAJOR USES:** Used in the production of disinfectants, preservatives, propionic acid, trimethylol ethane, pharmaceuticals, rubber chemicals, polyvinyl and other plastics.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from heat and oxidizers; outside or detached storage preferred.

**FIRE FIGHTING:** Use alcohol foam, carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; Short-Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) not established; IDLH not established.

**PERSONAL PROTECTION:** Wear rubber overclothing, including gloves; wear chemical safety goggles and self-contained breathing apparatus; enclose operations and use local ex-

haust ventilation at site of chemical release; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Stop or control leak if possible; use water spray to cool and disperse vapors, and dilute spills to form nonflammable mixtures; absorb liquid spills with rags or other available absorbing materials; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (nausea, vomiting, difficult breathing, narcosis, irritates eyes, nose and throat); eyes/skin (liquid causes irritation); ingestion (nausea, vomiting, loss of consciousness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1410 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and immediately wash skin with water and soap; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested drink water.

**KEY REFERENCES:** 3; 5; 6; 7; 11; 13; 14; 16.

### **PROPOXUR (C<sub>11</sub>H<sub>15</sub>O<sub>3</sub>N, 209.27)**

**CAS/DOT #:** 114-26-1

**SYNONYMS:** Aprocarb, baygon, o-isopropoxyphenyl-n-methylcarbamate.

**PHYSICAL PROPERTIES:** White to tan crystalline powder; faint characteristic odor; soluble in hot water and polar organic solvents; MP (85°C, 185°F); VP (0.1 mm Hg at 120°C).

**CHEMICAL PROPERTIES:** Stable under normal use conditions; unstable in high alkaline media; incompatible with strong oxidizers and alkalis; FP (>300°F).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: blurred vision; vomiting; sweating; tachycardia; cholinesterase inhibition in red blood cells; Chronic Risks: depressed cholinesterase levels; headache; vomiting; tumors in animals.

**HAZARD RISK:** Decomposition on heating emits highly toxic methyl isocyanate and nitrogen oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf3; U411; R4; A1; CAL.

**MAJOR USES:** Used as a nonfood insecticide to control cockroaches, flies, lawn and turf insects; malaria control; flea collars.

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV 0.5 mg/m<sup>3</sup>; OSHA PEL none; NIOSH REL TWA 0.5 mg/m<sup>3</sup>; IDLH not determined.

**PERSONAL PROTECTION:** Wear gas-tight suit and compressed air-oxygen apparatus; protective gloves are required; wear chemical safety goggles in combination with breathing protection; enclose operations and/or use local exhaust ventilation at site of chemical release; for extra personal protection, wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable containers; moisten first to prevent dusting; collect remaining material, then remove to safe place; do not wash away to sewer.

**HEALTH SYMPTOMS:** Inhalation (dizziness, headache, sweating, labored breathing, nausea, vomiting, loss of consciousness, muscle cramp, excessive salivation, pupillary constriction); skin (prickling); eyes (blurred vision, pupillary constriction); ingestion (abdominal cramps, diarrhea, weakness, muscle twitching, convulsions).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 70 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and immediately wash with large amounts of water and soap; if inhaled remove to fresh air and provide respiratory apparatus and oxygen as needed; if inhaled drink water and induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 16.

### **PROPYLENE DICHLORIDE (C<sub>3</sub>H<sub>6</sub>Cl<sub>2</sub>, 112.99)**

**CAS/DOT #:** 78-87-5/UN1279

**SYNONYMS:** Alpha,beta-dichloropropane, 1,2-dichloropropane, propylene chloride.

**PHYSICAL PROPERTIES:** Colorless liquid; sweet, chloroform-like odor; slightly soluble in water; miscible with organic solvents; MP (-100.4°C, -148.7°F); BP (96.4°C, 205.5°F); DN (1.159 g/mL at 25°C); ST (29 dynes/cm); VP (49.67 mm Hg at 25°C); VD (3.9).

**CHEMICAL PROPERTIES:** Flammable; sensitive to heat; reacts vigorously with oxidizers; FP (60°F); AT (1035°F); LFL (3.4%); UFL (14.5%); HC (-7300 Btu/lb); HV (8428.5 gcal/gmole).

**EXPOSURE ROUTES:** Inhalation (ambient air and wastewater evaporation); ingestion (contaminated drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: dermatitis; chest discomfort; drowsiness; cough; dyspnea; effects on blood, liver, kidneys, CNS, gastrointestinal system; Chronic Risks: tumors in animals.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat or flame; reactions with aluminum can lead to explosions; decomposition emits toxic fumes of Cl<sup>-</sup>; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Petroleum-based charcoal tube; acetone/cyclohexane; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sfl; U083; R3; R4; CAL.

**MAJOR USES:** Used in the production of rubber, perchloroethylene, carbon tetrachloride, dry cleaning fluids, insecticidal fumigants and spotting agents; used as a solvent for plastics, resins, oils and fats, gums, waxes and ethers.

**STORAGE:** Keep away from oxidizers and active metals; preferable to employ outside or detached storage.

**FIRE FIGHTING:** use water spray, appropriate foam, carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 75 ppm; ACGIH TLV STEL 110 ppm; OSHA PEL TWA 75 ppm (359mg/m<sup>3</sup>); OSHA PEL STEL 110 ppm; IDLH 400 ppm.

**PERSONAL PROTECTION:** wear protective coveralls and rubber footwear; wear chemical-resistant rubber gloves; wear splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; cautiously ignite paper in open areas, away from combustible materials; absorb large quantities with noncombustible materials such as dry earth or sand; flush remaining propylene dichloride with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (narcotic effects, liver and kidney necrosis, fatty degeneration of the liver, kidney or heart); contact (irritates eyes and mucous membranes, dermatitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2196 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash skin immediately with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested give water or milk.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 11; 13; 14; 16.

### PROPYLENE OXIDE (C<sub>3</sub>H<sub>6</sub>O, 58.09)

**CAS/DOT #:** 75-56-9/UN1280

**SYNONYMS:** 1,2-epoxypropane, methyloxirane, propene oxide, propylene epoxide.

**PHYSICAL PROPERTIES:** Colorless ethereal liquid; sweet, benzene-like odor; highly soluble in water; soluble in alcohol and ether; MP (-112.1°C, -169.8°F); BP (34.2°C, 93.6°F); DN (0.8304 g/mL at 20°C); ST (24.5 dynes/cm); VS (0.28 cP at 25°C); VP (445 mm Hg at 20°C); VD (2.0); OT (44 ppm).

**CHEMICAL PROPERTIES:** Extremely flammable; exothermic polymerization; reacts with metal chlorides, strong acids, caustics and peroxides; FP (-35°C); AT (449°C); LFL (2.3); UFL (36%); HC (-3000 Btu/lb); HV (205 Btu/lb).

**EXPOSURE ROUTES:** Inhalation (contaminated air), ingestion (fumigated food products and contaminated food), absorption; occupational exposure

**HUMAN HEALTH RISKS:** Inhalation man TCl<sub>o</sub> 1400 g/m<sup>3</sup> for 10 minutes; EPA Group B2 probable human carcinogen; Acute Risks: irritation of eyes, skin and respiratory tract; pulmonary edema; pneumonia; headache; coordination problems; CNS depression; ataxia; coma; Chronic Risks: tumors in animals.

**HAZARD RISK:** Very dangerous fire and explosion hazard when exposed to heat or flame; explosive reaction with epoxy resin, sodium hydroxide and oxygen; decomposition emits acrid smoke and fumes; NFPA Code: H 3; F 4; R 2.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; FIFRA; F7; C&Sf; Sf1; Sf2; Sf3; CWA; CW1; CW2; T799-18; A1; CAL.

**MAJOR USES:** Used in the production of brake fluid, insecticides, glycol ethers, polyurethane polyols, detergents, glycol ethers, dichloromethane and lubricants; sterilization of packaged food products in fumigation chambers.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from heat and open flame, acids, alkalis, salts and clay-based absorbents.

**FIRE FIGHTING:** Use alcohol foam, carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 20 ppm; OSHA PEL TWA 100 ppm (240mg/m<sup>3</sup>); IDLH 400 ppm.

**PERSONAL PROTECTION:** Wear special protective clothing, rubber gloves and boots; large and heavy face shields are recommended; use splash-proof safety goggles where liquid propylene oxide may contact the eyes; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** Ventilate area of spill or leak; use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in a fume hood; cautiously ignite paper in open areas away from combustible materials; dissolve large quantities in a flammable solvent such as alcohol and atomize in a suitable combustion chamber; do not use clay-based absorbents; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (headache, nausea, vomiting, mild depression of central nervous system, lung irritation, unconsciousness); contact (severe irritation of skin and eyes).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 380 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash skin with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested drink water.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 11; 13; 14; 16.

### 1,2-PROPYLENIMINE (C<sub>3</sub>H<sub>7</sub>N, 57.11)

**CAS/DOT #:** 75-55-8/UN1921

**SYNONYMS:** 2-methylaziridine, 2-methylethyleneimine, propylene imine.

**PHYSICAL PROPERTIES:** Fuming, colorless, oily liquid; ammonia-like odor; soluble in water; miscible with ethanol, chloroform and ether; BP (66°C, 151°F); MP (-65°C, -85°F); DN (0.81 g/cm<sup>3</sup> at 25°C); VD (2.0); VP (112 mm Hg at 20°C); HV (250 Btu/lb); OT (14 ppm).

**CHEMICAL PROPERTIES:** Flammable, corrosive; polymerizes when exposed to acids; hygroscopic; reacts vigorously with oxidizers; incompatible with acid and acid compounds; FP (-10°C); HC (-15500 Btu/lb).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure in paint and chemical industries.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, skin, mucous membranes and upper respiratory tract; headache; dizziness; bronchitis; edema of lungs; burns in mouth and stomach from ingestion; death; Chronic Risks: kidney, blood, and gastrointestinal effects; probable human carcinogen.

**HAZARD RISK:** Dangerous fire hazard; corrosive; flashback along vapor trail may occur; container explosion under fire conditions; polymerizes explosively; decomposition emits toxic fumes; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** C&Sf; Sf2; Sf3; A1; CAL.

**MAJOR USES:** Used in the production of latex surface coating resins, dyes, photographs, gelatins, agricultural chemicals, rocket propellant fuels and medicines; petroleum refining; rubber industry; paper industry.

**STORAGE:** Keep in a tightly closed container away from combustible materials and ignition sources; container may explode under fire conditions.

**FIRE FIGHTING:** Use carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm(skin); OSHA PEL TWA 2 ppm (5mg/m<sup>3</sup>)(skin); NOSH REL TWA (2 ppm (5mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear rubber overclothing (including boots, apron, and chemical-resistant gloves); wear chemical safety goggles or a face shield; wear positive pressure self-contained breathing apparatus; use in a fume hood.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; high efficiency particulate arrestor or charcoal filters can be used to minimize amount of carcinogen; solvent extraction, chemical destruction, or specially designed incinerators may be used to decontaminate spills; isolate and remove discharged material; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat, coughing, wheezing, laryngitis, burning sensation, shortness of breath, headache, dizziness, nausea, vomiting); contact (severe skin and eye irritant); ingestion (burns of the mouth and stomach).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 19 mg/kg; First aid: wash eyes with water for 30 minutes; if contact with skin occurs remove clothing and wash with water; in inhaled remove to fresh air and give artificial respiration and oxygen as needed; if ingested drink milk or water; in all cases seek immediate medical attention.

**KEY REFERENCES:** 3; 5; 6; 7; 11; 13; 14; 16.

**QUINOLINE (C<sub>9</sub>H<sub>7</sub>N, 129.17)**

**CAS/DOT #:** 91-22-5

**SYNONYMS:** 1-azanaphthalene, B-500, 1-benzine, chinoleine, leucoline.

**PHYSICAL PROPERTIES:** Colorless, hygroscopic liquid; darkens with age; penetrating, pungent odor; slightly soluble in cold water; soluble in hot water; miscible with alcohol, ether and carbon disulfide; MP (-15°C, 5°F); BP (237.7°C, 460°F); LSG (1.09); ST (45 dynes/cm at 20°C); VP (0.0091 mm Hg at 25°C); VD (4.45); VS (2.997 cP at 30°C).

**CHEMICAL PROPERTIES:** Volatile with steam; forms water-soluble salts with strong acids; attacks some plastics; AT(896°F); HC (-8710 cal/g); HV (86 cal/g).

**EXPOSURE ROUTES:** Inhalation (particulates and ambient air); ingestion (particulates); absorption; release in shale oil; occupational exposure in petroleum refining and coal industries.

**HUMAN HEALTH RISKS:** EPA Group C: possible human carcinogen; Acute Risks: irritation of eyes, nose and throat; headaches; dizziness; nausea; shortness of breath; coma; Chronic Risks: effects on liver and kidneys.

**HAZARD RISK:** Combustible when exposed to heat or flame; industrial explosions common; potentially explosive reaction with hydrogen peroxide; unpredictably violent; decomposition emits toxic fumes of nitrogen oxides; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; CWA; CW1; CW2; CAL.

**MAJOR USES:** Used in the production of fungistat, pharmaceuticals, 8-hydroxyquinoline, niacin, dyes, paints, flavoring and hydroxyquinoline sulfate; corrosion inhibitor; solvent for resins and terpenes.

**STORAGE:** Not available.

**FIRE FIGHTING:** Use water spray, dry chemical powder, appropriate foam or carbon dioxide.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; Short-Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) not established; IDLH not established.

**PERSONAL PROTECTION:** Wear a gas-tight, fireproof suit and compressed air/oxygen apparatus; wear chemical-resistant gloves (Note: rubber and plastic gloves are not recommended because pyridine and many of its derivatives penetrate these materials); wear self-contained breathing apparatus and chemical-safety goggles.

**SPILL CLEAN-UP:** Cover spill with a thick layer of sand and soda ash mixture (90-10); mix and shovel into a heavy paper carton stuffed with much paper packing.

**HEALTH SYMPTOMS:** Inhalation (headache, dizziness, nausea, irritates nose and throat); eyes (redness, irritation); skin (redness, irritation); ingestion (nausea, vomiting, irritates mouth and stomach).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 331 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash skin with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested drink water.

**KEY REFERENCES:** 2; 3; 5; 6; 7; 11; 13; 14; 16.

### **QUINONE (C<sub>6</sub>H<sub>4</sub>O<sub>2</sub>, 108.10)**

**CAS/DOT #:** 106-51-4/UN2587

**SYNONYMS:** 1,4-Benzoquinone, p-benzoquinone, chinone, 1,4-cyclohexadiene, 2,5-cyclohexadiene-1,4-dione, p-quinone.

**PHYSICAL PROPERTIES:** Solid pale yellow-green prisms; chlorine-like odor; slightly soluble in water; BP (sublimes); MP (115.7°C, 240.3°F); LSG (1.3180); VP (0.1 mm Hg at 25°C); OT (0.400 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** Combustible solid; may darken in air; FP (38°C); AT (560°C); HC (656.6 kcal/gmol at 25°C).

**EXPOSURE ROUTES:** Inhalation (tobacco smoke); absorption; occupational exposure in dye, textile, chemical, tanning and cosmetic industries.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes and skin; generalized swelling; skin discoloration; dermatitis; erythema; discoloration of the conjunctiva and cornea; Chronic Risks: skin ulceration; visual disturbances; necrosis; permanent eye damage.

**HAZARD RISK:** When moist, self-heats and decomposes exothermically at temperatures above 60°C; decomposition emits acrid smoke and fumes of carbon monoxide and carbon dioxide; NFPA Code: not available.

**MEASUREMENT METHODS:** XAD tube; ethanol/hexane; high pressure liquid chromatography with UV detection.

**APPLICABLE REGULATIONS:** CA2; C&Sf; CAL; T-120a; A1.

**MAJOR USES:** Used in the production of fungicides, pharmaceuticals, cortisone, leather, gelatin, cosmetics and pH electrodes; strengthens animal fibers; polymerization inhibitor.

**STORAGE:** Keep in a tightly closed container in a cool, dry, well-ventilated area away from incompatible substances.

**FIRE FIGHTING:** Use water spray, dry chemical powder or carbon dioxide.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; OSHA PEL TWA 0.1 ppm (0.4mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.4 mg/m<sup>3</sup>); IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear protective clothing, boots, apron, etc.; wear chemical-resistant gloves; wear chemical-safety goggles; wear self-contained breathing apparatus; avoid contact with solid or dust.

**SPILL CLEAN-UP:** Ventilate area of spill; sweep small quantities onto paper or suitable material and ignite in safe place, such as a fume hood; dissolve large quantities in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber equipped with afterburner and scrubber; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (eye irritation, conjunctivitis); contact (severe skin damage, destructive to mucous membranes, skin discoloration, erythema, generalized swelling, papules, vesicles, photophobia, eye lacrimation, cornea ulceration and scarring, brownish discoloration of the cornea, and damage in corneal structure).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 130 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and immediately wash skin with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested drink water.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 13; 14; 16.

**RADIONUCLIDES (Ra, U, Rn, etc. Formula weight varies by radionuclide. Ra: 226.03, U: 238.03, Rn: 222)**

**CAS/DOT #:** Varies by compound.

**SYNONYMS:** Not available.

**PHYSICAL PROPERTIES:** U: Silver; contains U-239, U-235, U-238 isotopes; insoluble in water; soluble in acids; MP (1132.3°C, 2070°F); BP (3818°C, 6904°F); DN (19.05 g/mL at 20°C); VP (1 mm Hg at 2450°C); Ra: Silvery-white; decays in water and acids; MP (700°C, 1292°F); BP (<1140°C, 2084°F); DN (5 g/mL at 20°C); Rn: Colorless, odorless radioactive gas; soluble in water; slightly soluble in alcohol; MP (71°C, 160°F); BP (61.8°C, 143°F); DN (0.00996 g/mL at 20°C); VP (400 mm Hg at 25.8°C).

**CHEMICAL PROPERTIES:** U: AT (1472°F).

**EXPOSURE ROUTES:** Inhalation (homes and buildings); ingestion (contaminated food and drinking water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: no information available in humans; Chronic Risks: Uranium: kidney effects; lung cancer; tumors; nonmalignant respiratory disease; Radium: acute leukopenia; tumors in lungs, bones, brain and nasal passage; necrosis of jaw; terminal bronchopneumonia; Chronic Risks: Radon: chronic lung disease; fibrosis of lung; effects on blood; lung cancer; decrease in body weight.

**HAZARD RISK:** U: pyrophoric in finely divided state; combustion produces uranium oxide.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; C&Sf.

**MAJOR USES:** U: nuclear power plants; nuclear weapons; ceramics; photographic chemicals; light bulbs; Ra: radiography of metals; neutron source for research; Rn: treating malignant tumors; experimental studies.

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV (insoluble compounds) 0.2 mg/m<sup>3</sup>; OSHA PEL TWA (soluble compounds) 0.05 mg/m<sup>3</sup> OSHA PEL TWA (insoluble compounds) 0.2 mg/m<sup>3</sup>; NIOSH REL (insoluble compounds) 0.15 mg/m<sup>3</sup> NIOSH REL (soluble compounds) 0.05 mg/m<sup>3</sup>; NCRP (indoor air guideline) 8 pCi/L; EPA (indoor air action level and guideline for schools) 4 pCi/L.

**PERSONAL PROTECTION:** Not available.

**SPILL CLEAN-UP:** Ventilate area of spill; collect spilled material and deposit in sealed containers; liquid containing uranium or insoluble uranium compounds, for example, should be absorbed in sand or other inert material; spilled uranium chips or turnings should be covered with oil in order to prevent fire.

**HEALTH SYMPTOMS:** Inhalation (lung cancer, blood changes); ingestion (tumors of the lung, bone, brain, and nasal passages).

**GENERAL COMMENTS:** Original NESHAP; First aid: wash eyes immediately with large amounts of water; wash contaminated skin with plenty of soap and water; administer oxygen if breathing is difficult; if breathing has stopped, provide respiratory support.

**KEY REFERENCES:** 5; 11; 13; 14; 16, 17.

### **SELENIUM COMPOUNDS (SeX; formula weight varies by compound; the formula weight for hydrogen selenide is 80.98)**

**CAS/DOT #:** Varies by compound, Se: 7782-49-2/UN2658

**SYNONYMS:** Vary by compound.

**PHYSICAL PROPERTIES:** Hydrogen Selenide: Colorless gas; unpleasant odor; soluble in water, carbon disulfide and carbonyl chloride; MP (-67.7°C, -90°F); BP (41.3°C, 106°F); DN (2.12 g/mL at 42°C); VP (1330 mm Hg at 30°C); Sodium Selenite/Selenate: White or colorless crystals; soluble in water; Selenium Sulfide: Bright red-yellow powder; insoluble in water; MP (118°C, 244°F); DN (3.056 g/mL at 0°C).

**CHEMICAL PROPERTIES:** Se: Violently reacts with barium carbide, nitric acid, metals and metal salts; Sodium Selenide/Selenite: not flammable.

**EXPOSURE ROUTES:** Inhalation (combustion of coal, fly ash and volcanic eruptions); ingestion (locally grown food and water); absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Selenium Sulfide: EPA Group B2 probable human carcinogen; Acute Risks: irritation of eyes and mucous membranes; bronchial spasms; bronchitis; chemical pneumonia; headache; indigestion; cardiovascular effects; liver effects; fatigue; nose-bleed; nausea; vomiting; chills; tremors; blind "staggers" disease; Chronic Risks: nose irritation;

sputum; burns; numbness; brittle hair; tooth decay; lack of mental alertness; skin discoloration; rashes; dermatitis; paralysis; nail loss; "Keshan disease".

**HAZARD RISK:** Reacts with metal amides to form explosive products; decomposition emits toxic fumes; NFPA Code: not available.

**MEASUREMENT METHODS:** Particulate filter; acid; atomic absorption spectrometry.

**APPLICABLE REGULATIONS:** CA2; C&Sf; CW3.

**MAJOR USES:** Used in the production of enamels, pesticides, rubber, paints, glass, enamels, inks, dandruff shampoos, plastics, fungicides and lubricants.

**STORAGE:** Keep in a dry area away from strong oxidizers, acids, food and feedstuffs.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg (5e)/m<sup>3</sup>; OSHA PEL TWA 0.2 mg (selenium compounds)/m<sup>3</sup>; NIOSH REL TWA 0.2 mg (selenium compounds)/m<sup>3</sup>; NIOSH IDLH 100 mg (selenium compounds)/m<sup>3</sup>.

**PERSONAL PROTECTION:** Wear impervious clothing, gloves, and face shields; use dust and splash-proof safety goggles; use any self-contained breathing apparatus operated in a positive pressure mode; facilities, such as showers and eyewash fountains, should be provided within immediate work area for emergency use.

**SPILL CLEAN-UP:** Ventilate area of spill; liquid containing selenium and its inorganic compounds should be absorbed in vermiculite, dry earth, or sand.

**HEALTH SYMPTOMS:** Inhalation (shallow breathing, irritates eyes, skin, nose, and throat); contact (chills, fever, headache, superficial skin burns, nervousness, depression); ingestion (gastrointestinal disturbances, metallic taste, garlic odor of breath, diarrhea, excessive salivation).

**GENERAL COMMENTS:** Se: Oral rat LD<sub>50</sub> 6700 mg/kg; First aid: wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**KEY REFERENCES:** 4; 7; 13; 14; 16

### **STYRENE (C<sub>8</sub>H<sub>8</sub>, 104.16)**

**CAS/DOT #:** 100-42-5/UN2055

**SYNONYMS:** Cinnamene, phenylethylene, styrol, vinyl-benzene.

**PHYSICAL PROPERTIES:** Colorless to pale yellow liquid; oily; sweet odor; slightly soluble in water; miscible with alcohol and ether; BP (145.2°C, 293.4°F); MP (-30.63°C, -23.1°F); LSG (0.91); ST (32.14 dynes/cm); VS (0.751 mP); VD (3.6).

**CHEMICAL PROPERTIES:** Slowly polymerizes when exposed to light and air; corrodes copper and copper alloys; FP (88°F); AT (914°F); LFL (1.1%); UFL (6.1%); HC (4381 kJ/mol at 20°C); HV (86.8 cal/g).

**EXPOSURE ROUTES:** Inhalation (indoor air, building material emissions, consumer product emissions, tobacco smoke and ambient air); occupational exposure in reinforced plastic and polystyrene industries.

**HUMAN HEALTH RISKS:** Inhalation human TCLo 10,000 ppm for 30 minutes; EPA Group C: possible human carcinogen; Acute Risks: irritation of eyes and mucous membranes; gastrointestinal effects: headache; vomiting; drowsiness; dermatitis; CNS depression; Chronic Risks: CNS effects; fatigue; depression; peripheral neuropathy; effects on blood; increased risk of leukemia and lymphoma.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat, flame or oxidizers; explosive in the form of vapor when exposed to heat or flame; storage hazard above 32°C; violent polymerization; reacts vigorously with oxidizers; decomposition emits acrid smoke and fumes; NFPA Code: H 2; F 3; R 2.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; C&Sf; S2; S32; S50-b; S61; S62; R2; R3; R5; CW1; CW2; A1; A2; CAL.

**MAJOR USES:** Used in the production of polystyrene, resins, plastics, rubber, boats, ice cream, candy, paints, coatings, copolymers, styrenated phenols and oils.

**STORAGE:** Keep in a tightly closed container away from heat, sparks, and open flame; light sensitive.

**FIRE FIGHTING:** Use appropriate foam, carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; ACGIH TLV STEL 100 ppm (skin); OSHA PEL TWA 100 ppm; OSHA PEL CL 200 ppm; OSHA PEL 600 ppm/5M/3H; NIOSH REL TWA 50 ppm (215 mg/m<sup>3</sup>); NIOSH REL STEL 100 ppm (425 mg/m<sup>3</sup>); IDLH 700 ppm.

**PERSONAL PROTECTION:** Wear full protective clothing (boots, apron, chemical-resistant gloves, etc.); wear chemical safety goggles; use self-contained breathing apparatus in high vapor concentrations; a full-facepiece is recommended above 400 ppm.

**SPILL CLEAN-UP:** Use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in a fume hood; absorb large quantities in non-combustible material and atomize in a suitable combustion chamber; mixing styrene with a more flammable solvent may also improve combustion; remove all ignition sources.

**HEALTH SYMPTOMS:** Inhalation (eye and olfactory changes, irritation and violent itching of the eyes, lacrimation, anesthetic or narcotic effect); contact (defatting dermatitis).

**GENERAL COMMENTS:** Oral-rat LD<sub>50</sub> 5000 mg/kg; First aid: immediately wash eyes and skin with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested rinse mouth out with water.

**KEY REFERENCES:** 3; 4; 7; 10; 13; 14; 16.

**STYRENE OXIDE (C<sub>8</sub>H<sub>8</sub>O, 120.16)**

**CAS/DOT #:** 96-09-3

**SYNONYMS:** Epoxyethylbenzene, expoxystyrene, phenethylene oxide, styrene epoxide.

**PHYSICAL PROPERTIES:** Colorless to pale straw-colored liquid; sweet odor; slightly soluble in water; miscible with acetone, benzene, ether and methanol; BP (194.2°C, 381.6°F); MP (-36.7°C, -34.1°F); LSG (1.0469); VP (0.3 mm Hg at 20°C); VD (4.14); OT (0.4 ppm).

**CHEMICAL PROPERTIES:** Combustible; stable under normal conditions; may polymerize under conditions of heating, acids, bases and certain metal salts; FP (74°C); AT (498°C); LFL (1.1%); UFL (22%).

**EXPOSURE ROUTES:** Inhalation (emissions during production and use); released to environment in wastewater; occupational exposure.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of skin, eyes and digestive tract; burning sensation; diarrhea; nausea; CNS depression; drowsiness; abdominal pain; shock; collapse; lowering of consciousness; Chronic Risks skin sensitization; possibly carcinogenic in humans.

**HAZARD RISK:** Flammable when exposed to heat, flame and oxidizers; may polymerize; explosive vapor/air mixtures may form; decomposition emits acrid smoke and fumes of carbon monoxide and carbon dioxide; NFPA Code: H 2; F 2; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; C&Sf; CAL.

**MAJOR USES:** Used in the production of styrene glycol and its derivatives, cosmetics, surface coatings and agricultural and biological chemicals; diluent for epoxy resins.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from acids, metal salts, and bases; keep away from heat, sparks, and flame.

**FIRE FIGHTING:** Use appropriate foam, carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** Threshold Limits Value (TLV) not established; Short Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) not established.

**PERSONAL PROTECTION:** Wear gas-tight, fireproof suit and compressed air/oxygen apparatus; wear face shield or eye protection in combination with breathing protection; above the flash point, use a closed system of local exhaust ventilation; for extra personal protection, self-contained breathing apparatus is recommended.

**SPILL CLEAN-UP:** Collect leaking liquid in sealable containers, or absorb in sand or inert absorbent and remove to safe place; do not allow this chemical to enter the environment.

**HEALTH SYMPTOMS:** Inhalation (dizziness, drowsiness, vomiting, unconsciousness); skin (redness, skin burns); eyes (redness, pain, severe deep burns); ingestion (burning sensation, abdominal pain, diarrhea, nausea, shock, collapse).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2000 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash skin immediately with large amounts of water and soap; if inhaled remove to fresh air and provide respiratory support as needed; if ingested give water and induce vomiting as long as victim is conscious.

**KEY REFERENCES:** 6; 7; 13; 14; 16.

### **2,3,7,8-TETRACHLORODIBENZO-p-DIOXIN (C<sub>12</sub>H<sub>4</sub>Cl<sub>4</sub>O<sub>2</sub>, 321.96)**

**CAS/DOT #:** 1746-01-6

**SYNONYMS:** Dioxin, dioxine, TCBDDB, TCDD, 2,3,7,8-TCDD, tetradoxin.

**PHYSICAL PROPERTIES:** White, crystalline solid or colorless needles; slightly soluble in water; BP (412.2°C, 774°F); MP (305°C, 581°F); DN (1.827 g/mL at 20°C); VP (1.52E-09 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Caustic.

**EXPOSURE ROUTES:** Inhalation (fly ash, soot particles, flue gases, ambient air, incineration fumes, herbicides and wood dust), ingestion (urban vegetation, fish and cow's milk), occupational exposure in pulp and paper, wood industries.

**HUMAN HEALTH RISKS:** Skin human TDLo 107 g/kg; EPA Group 2B: probable human carcinogen; Acute Risks: irritation of skin and eyes; tightness in chest; dizziness; headache; nausea; allergic dermatitis; hepatic necrosis; thymic atrophy; hemorrhage; chloracne; Chronic Risks: skin lesions; chloracne; severe weight loss; pancreatic, bronchogenic carcinoma; gastric ulcers; delayed death.

**HAZARD RISK:** Most toxic member of the dioxin family; caustic and corrosive; decomposition emits toxic fumes of Cl; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; S1; S24; S32; S50-a; S61; R4; R5; R6; C&Sf; Sfl; CW3; CW4; CW5; CAL.

**MAJOR USES:** Byproduct of herbicides, defoliants and Agent Orange; research chemical; wood preservative (not commercially).

**STORAGE:** Not available.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV not established; OSHA PEL none; NIOSH REL TWA not established; potential occupational carcinogen; IDLH not determined, potential occupational.

**PERSONAL PROTECTION:** Wear gastight suit and viton7 rubber gloves; wear approved chemical safety goggles; material should be handled or transferred in an approved fume hood or with adequate ventilation; electrically ground all equipment when handling this product; a NIOSH approved air supplied respirator is recommended in absence of proper environmental controls; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Consider evacuation; contain release and eliminate its source, if this can be done without risk; remove any sources of ignition until the area is determined to be free from explosion or fire hazards.

**HEALTH SYMPTOMS:** Inhalation (headache, dizziness, hallucinations, changes in motor activity, nausea, respiratory irritation); skin (prickling, allergic dermatitis); eyes (severe irritation); ingestion (dizziness, headache, nausea, drowsiness, tightness of chest).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 20 g/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and flush skin with large amounts of water and soap; if inhaled remove to fresh air and provide respiratory assistance as needed.

**KEY REFERENCES:** 3; 6; 7; 14; 16, 17.

### **1,1,2,2-TETRACHLOROETHANE (C<sub>2</sub>H<sub>2</sub>Cl<sub>4</sub>, 167.84)**

**CAS/DOT #:** 79-34-5/UN1702

**SYNONYMS:** Acetylene tetrachloride, bonoform, cellon, sym-tetrachloroethane, westron.

**PHYSICAL PROPERTIES:** Dense, colorless liquid; pungent odor; slightly soluble in water; miscible with benzene, ether, methanol and other organic liquids; BP (146.4°C, 295.5°F); MP (-43.8°C, -46.8°F); DN (1.593 g/cm<sup>3</sup> at 25°C); VD (5.8); OT (1.5 ppm); VP (8 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Nonflammable; corrosive; stable; reacts violently with sodium, potassium and dinitrogen tetraoxide; incompatible with strong oxidizers, bases and strong reducing agents.

**EXPOSURE ROUTES:** Inhalation; absorption; ingestion; detected in surface water and groundwater; occupational exposure.

**HUMAN HEALTH RISKS:** Oral human TDLo 30 mg/kg; inhalation human TCLo 1000 mg/m<sup>3</sup> for 30 minutes; Acute Risks: irritation of eyes, mucous membranes and upper respiratory tract; burning sensation; coughing; dermatitis; CNS depression; gastrointestinal effects; death; Chronic Risks: blood effects; heart damage; possible human carcinogen; jaundice; CNS effects; may alter genetic material.

**HAZARD RISK:** Corrosive; decomposition emits toxic fumes of carbon monoxide, carbon dioxide and hydrogen chloride; NFPA Code: not available.

**MEASUREMENT METHODS:** Petroleum based charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA1; S3; S40-e; R2; R3; R4; R5; R7; R8; U(U waste); C&Sf; Sfl; Sf3; CWA; CW4; CW5; A1.

**MAJOR USES:** Used in the production of paint removers, resins, waxes, insecticides, weed killers, fumigants, trichloroethylene and tetrachloroethylene; photographic development; degreasing and cleaning of metals.

**STORAGE:** Keep in a tightly closed container away from strong bases, strong oxidizing or reducing agents and metals.

**FIRE FIGHTING:** Use water spray, carbon dioxide, dry chemical powder or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm (6.9 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 5 ppm (35 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 1 ppm (7 mg/m<sup>3</sup>)(skin) reduce to lowest level; IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; use a system of local exhaust ventilation to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers or absorb with an inert material (e.g., dry earth, sand, vermiculite); flush remaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (cough, wheezing, sore throat, shortness of breath, headache, dizziness, nausea, vomiting, abdominal pain); skin absorption (tremors, restlessness, somnolence, delirium, dizziness, nausea, vomiting); skin contact (dry skin, redness, itching, pain); eye contact (severe irritation, tearing, corneal burns, eye damage); ingestion (irritates gastrointestinal tract, nausea, vomiting, diarrhea, salivation).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 250 mg/kg; First aid: wash eyes and skin with water for 15 minutes; remove clothing; if inhaled remove to fresh air and give artificial respiration or oxygen as needed; if ingested induce vomiting and immediately contact poison control center; in all cases immediately seek medical assistance.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 16.

### **TETRACHLOROETHYLENE (C<sub>2</sub>Cl<sub>4</sub>, 165.82)**

**CAS/DOT #:** 127-18-4/UN1897

**SYNONYMS:** Ethylene tetrachloride, perchloroethylene, tetracap.

**PHYSICAL PROPERTIES:** Colorless liquid; sharp, sweet odor; insoluble in water; miscible with alcohol, ether, chloroform and benzene; MP (-23.35°C, -10.3°F); BP (121.2°C, 250.2°F); LSG (1.631); VD (5.83); VP (18.47 mm Hg at 25°C); OT (4.68 ppm).

**CHEMICAL PROPERTIES:** Nonflammable; stable.

**EXPOSURE ROUTES:** Inhalation (ambient air and dry cleaning establishments); ingestion (contaminated drinking water); absorption (suede, auto brake cleaners and water repellents); occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TCl<sub>o</sub> 96 ppm for 7 hours; EPA Group B2/C: probable human carcinogen; Acute Risks: irritation of eyes, upper respiratory tract and skin; flushing of face and neck; dizziness; headache; CNS effects; anesthetic effects; coordination impairment; kidney dysfunction; death; Chronic Effects: memory and concentration impairment; cardiac arrhythmia; menstrual disorders; spontaneous abortions; kidney effects; tumors.

**HAZARD RISK:** Extremely stable; resists hydrolysis; reacts violently with barium, beryllium, lithium and sodium hydroxide; decomposition emits toxic fumes of Cl<sup>-</sup>; NFPA Code: H 2; F 0; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; S1; S32; S50-a; S61; S62; S10; R2; R4; R5; R7; R8; R9; D039; U210; C&Sf; Sfl; Sf3; CWA; CW3; CW4; CW5; A2; CAL.

**MAJOR USES:** Used in the production of rubber coatings, solvent soaps, printing inks, adhesives, glues, sealants, polishes, lubricants and insulating fluids; dry cleaning; textile processing.

**STORAGE:** Keep in a well-ventilated, dark area along the floor, away from metals, food and feedstuffs.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50ppm; ACGIH TLV STEL 200 ppm; OSHA PEL TWA 100 ppm; OSHA PEL CL 200 ppm; NIOSH REL TWA minimize workplace exposure; IDLH 150 ppm.

**PERSONAL PROTECTION:** wear full protective clothing (rubber boots, aprons, sleeves, gas-tight suit, etc.); wear chemical resistant gloves; wear chemical safety goggles and positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible in non-combustible materials such as dry earth, sand or vermiculite.

**HEALTH SYMPTOMS:** inhalation (anesthetic effects, conjunctiva irritation, hallucinations, distorted perceptions, pulmonary changes, coma); ingestion (irritates the gastrointestinal tract, nausea, vomiting, abdominal pain, diarrhea); contact (dermatitis, severe eye and skin irritation).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2629 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash skin with large amounts of water and soap; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested drink water and induce vomiting.

**KEY REFERENCES:** 3; 4; 6; 7; 10; 13; 14; 16.

**TITANIUM TETRACHLORIDE (TiCl<sub>4</sub>, 189.70)**

**CAS/DOT #:** 7550-45-0/UN1838

**SYNONYMS:** Titanic chloride, titanium (IV) chloride.

**PHYSICAL PROPERTIES:** Colorless to light yellow to red fuming liquid; strong acid odor; MP (-24°C, -11°F); BP (136°C, 278°F); LSG (2.23); VP (9.6 mm Hg at 22C).

**CHEMICAL PROPERTIES:** Corrosive; reacts violently with water; absorbs moisture from air; attacks many metals in presence of water; HV (79.7 BTU/lb).

**EXPOSURE ROUTES:** Inhalation or absorption during manufacture or use.

**HUMAN HEALTH RISKS:** Acute risks: irritation of eyes, skin and mucous membranes; congestion in pharynx and trachea; skin burns; stenosis of upper respiratory system; cornea damage; polyps; Chronic Risks: chronic bronchitis; bronchial constriction; wheezing; chemical pneumonitis; pulmonary edema.

**HAZARD RISK:** Non-combustible; corrosive; incompatible with strong oxidizers; violent reaction with water; decomposition emits dense white clouds and toxic fumes of Cl<sub>2</sub>; NFPA Code: H 3; F 0; R 2.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; C&Sf; Sf2; Sf3; CAL.

**MAJOR USES:** Used in the production of titanium metal, titanium pigments, iridescent glass, artificial pearls and smoke screens; implant material in orthopedics, oral surgery and neurosurgery; laboratory reagent.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from water.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam; do not use water spray.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV/TWA) not established; OSHA PEL none; NIOSH REL none; IDLH not determined; AIHA Workplace Environmental Exposure Level 0.5 mg/m<sup>3</sup> (TWA).

**PERSONAL PROTECTION:** Wear rubber or neoprene gloves and additional protective clothing, including boots, apron or coveralls; use chemical safety goggles and/or a full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; wear a full-facepiece self-contained breathing apparatus; all equipment should be acid resistant; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Ventilate area of leak or spill; neutralize spill with soda ash or lime, then absorb with inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; do not flush to sewer; do not contact with water.

**HEALTH SYMPTOMS:** Inhalation (burning sensation, coughing, wheezing, shortness of breath, laryngitis, headache, nausea, vomiting); skin (blistering burns, irritation, pain); eyes (severe burns, permanent eye damage); ingestion (abdominal pain, nausea, vomiting, burning pain in throat).

**GENERAL COMMENTS:** First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested drink water and induce vomiting.

**KEY REFERENCES:** 3; 6; 7; 10; 13; 14; 16.

### **TOLUENE (C<sub>7</sub>H<sub>8</sub>, 92.15)**

**CAS/DOT #:** 108-88-3/UN1294

**SYNONYMS:** Methylbenzene, phenylmethane, toluol.

**PHYSICAL PROPERTIES:** Colorless liquid; sweet aromatic odor; insoluble in water; miscible with alcohol, chloroform, ether and acetone; MP (-95°C, -139°F); BP (111°C, 232°F); VP (36.7 mm Hg at 30C); VS (0.590 cP at 20C); ST (29.0 dynes/cm); LSG (0.87).

**CHEMICAL PROPERTIES:** Flammable liquid; reacts with oxidizing materials; FP (40°F); AT (480°C); LFL (1.2%); UFL (7.1%); HC (-17430 BTU/lb).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure.

**HUMAN HEALTH RISKS:** Oral human LDLo 50 mg/kg; eye human 300 ppm; inhalation human TCLo 200 ppm; Acute Risks: irritation of eyes, skin and upper respiratory tract; burning sensation; headache; shortness of breath; nausea; chest pain; edema; death; Chronic Risks: dermatitis; anemia; decreased blood cell count; bone marrow hypoplasia; CNS effects.

**HAZARD RISK:** Very dangerous fire hazard; explodes in vapor form when exposed to heat or flame; explosive reactions with tetranitromethane, nitric acid and sulfuric acid; reacts violently with oxidizers; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; S1; S32; S50-b; S61; S62; S10; R2; R3; R4; R5; R6; R8; R9; U (U waste); C&Sf; Sf1; Sf3; CWA; CW1; CW2; CW3; CW4; CW5; T120-a; A2; CAL.

**MAJOR USES:** Used in the production of benzoic acid, dyes, saccharin, perfumes, explosives, detergent, medicines; used as a solvent in paints, resins, gums, plastic toys and model airplanes.

**STORAGE:** Keep in a cool, dry area away from sparks, heat and open flame; keep away from oxidizers.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (skin); OSHA PEL TWA 200 ppm; OSHA PEL CL 300 ppm; OSHA PEL 500 ppm/10m max. peak; NIOSH REL TWA 100 ppm (375mg/m<sup>3</sup>); NIOSH REL STEL 150 ppm (560 mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** Impervious outerwear should be worn; wear chemical-resistant gloves; rubber is not recommended; wear safety goggles and self-contained breathing apparatus; drench-type showers and eye-wash fountains should be provided.

**SPILL CLEAN-UP:** Use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in fume hood; absorb as much as possible in noncombustible materials such as dry earth or sand; flush remaining toluene with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (central nervous system effects, hallucinations, distorted perceptions, motor activity changes, bone marrow changes, irritates eyes and skin); skin absorption (dizziness, headache, anesthesia, respiratory arrest); contact (dryness of skin, dermatitis); ingestion (vomiting, diarrhea, depressed respiration).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5000 mg/kg; First aid: immediately wash eyes with large amounts of water; wash exposed clothing before wearing again; if inhaled remove to fresh air and provide respiratory support as needed.

**KEY REFERENCES:** 3; 4; 6; 7; 10; 13; 14; 16.

### 2,4-TOLUENE DIAMINE (C<sub>7</sub>H<sub>10</sub>N<sub>2</sub>, 122.19)

**CAS/DOT #:** 95-80-7/UN1709

**SYNONYMS:** Diaminotoluene, methylphenylene diamine, TDA, tolylenediamine.

**PHYSICAL PROPERTIES:** Colorless crystals; very soluble in hot water; MP (99°C, 210°F); BP (283°C, 541°F); VP (1 hPa at 106°C).

**CHEMICAL PROPERTIES:** Stable; incompatible with acids, acid chlorides, acid anhydrides, chloroformates and strong oxidizers; FP (300°F); AT (365°C).

**EXPOSURE ROUTES:** Inhalation (air in polyurethane plants); ingestion (contaminated drinking water); absorption from wastewater.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: irritation of eyes and skin; permanent blindness; rise in blood pressure; dizziness; convulsions; asthma; coma; Chronic Risks: blood, liver and CNS effects.

**HAZARD RISK:** Decomposition emits toxic fumes of nitrogen, nitrous oxides, carbon monoxide and carbon dioxide; NFPA Code: not available.

**MEASUREMENT METHODS:** Impinger; reagent; high pressure liquid chromatography with UV detection

**APPLICABLE REGULATIONS:** CA2; R4.

**MAJOR USES:** Used in the production of dyes, polyurethane, toluene diisocyanate, impact resistant resins and hydraulic fluids; enhancement of thermal stability in polydimides.

**STORAGE:** Keep in a tightly closed container in a cool, dry, well-ventilated area away from incompatible substances.

**FIRE FIGHTING:** Use water spray, dry chemical powder, chemical foam or alcohol-resistant foam.

**EXPOSURE GUIDELINES:** Threshold Limits Value (TLV) not established; OSHA PEL none; NIOSH REL (all isomers) potential occupational carcinogen; NIOSH IDLH (no data) potential occupational carcinogen.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, lab coat, apron, coveralls, and heat-insulating gloves (if in molten state); wear chemical safety goggles (if molten) and face shield; enclose operations and use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Collect leaking and spilled liquid in sealable containers; vacuum spilled substance, then remove to a safe place, consult on expert when attempting to clean up this chemical.

**HEALTH SYMPTOMS:** Inhalation (blue skin, blue lips or fingernails, dizziness, increased heart rate, labored breathing, nausea, vomiting, convulsions, respiratory depression); skin (redness on contact with molten material, skin burns, blisters); eyes (redness); ingestion (abdominal pain, blue skin, headache, nausea, vomiting).

**GENERAL COMMENTS:** First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and immediately wash with large amounts of water and soap; if inhaled remove to fresh air.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 13; 14; 16.

## 2,4-TOLUENE DIISOCYANATE (C<sub>9</sub>H<sub>6</sub>N<sub>2</sub>O<sub>2</sub>, 174.16)

**CAS/DOT #:** 584-84-9/UN2078

**SYNONYMS:** Cresorcinol diisocyanate, isocyanic acid, toluene diisocyanate, TDI.

**PHYSICAL PROPERTIES:** Colorless or light yellow liquid; turns pale yellow on exposure to air; sharp, pungent odor; MP (20-22°C, 67-71°F); BP (251°C, 484°F); LSG (1.22); VP (1 mm Hg at 80°C); OT (0.17 ppm).

**CHEMICAL PROPERTIES:** Reacts violently with organic acids, bases, amines, alcohols and organometallic compounds; hazardous decomposition in water; hazardous polymerization will occur; FP (127°C); AT (619°C); LFL (0.9%); UFL (9.5%).

**EXPOSURE ROUTES:** Inhalation (indoor air); adsorption through skin and eyes; occupational exposure in polyurethane foam industry.

**HUMAN HEALTH RISKS:** Acute risks: irritation of skin, eyes and upper respiratory tract; asthma; gastrointestinal effects; death; Chronic Risks: weight loss; bronchopneumonia; blood, liver, kidney effects.

**HAZARD RISK:** Combustible; closed containers may explode under heat; violent polymerization with bases or acyl chlorides; decomposition emits toxic fumes of nitrogen oxides and isocyanate; NFPA Code: H 3; F 1; R 1.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CA2; C&Sf; Sf2; A1; CAL.

**MAJOR USES:** Used in the production of polyurethane foam, coatings and elastomers.

**STORAGE:** Keep under nitrogen in a tightly closed container in a dry, well-ventilated area; refrigerate (20-25°C).

**FIRE FIGHTING:** Use carbon dioxide or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.005 ppm (0.036 mg/m<sup>3</sup>); ACGIH TLV STEL 0.02 ppm (0.143 mg/m<sup>3</sup>); OSHA PEL TWA 0.005 ppm (0.036 mg/m<sup>3</sup>); OSHA PEL STEL 0.02 ppm (0.143 mg/m<sup>3</sup>); NIOSH REL TWA 0.005 ppm; NIOSH REL CL 0.02 ppm/10M; IDLH 2.5 ppm.

**PERSONAL PROTECTION:** Wear special protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** Use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; flush remaining contaminant with large amounts of water but not into spaces such as sewers because of danger of explosions; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (respiratory obstruction, cough, sputum, pulmonary effects, gastrointestinal changes, irritates eyes, skin and nose); contact (severe dermatitis, bronchial spasm, conjunctivitis, lacrimation, skin sensitization).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5800 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash skin; wash clothes prior to reuse; if inhaled remove to fresh air and provide respiratory apparatus as needed.

**KEY REFERENCES:** 3; 4; 6; 7; 10; 13; 14; 16.

### **o-TOLUIDINE (C<sub>7</sub>H<sub>9</sub>N, 107.17)**

**CAS/DOT #:** 95-53-4/UN1708

**SYNONYMS:** 2-Aminotoluene, ortho-methylaniline, 2-methylaniline, 1,2-toluidine.

**PHYSICAL PROPERTIES:** Light yellow or colorless liquid; aromatic odor; slightly soluble in water; miscible with alcohol, ether and dilute acids; MP (-14.7°C, 5°F); BP (200.2°C, 392°F); LSG (1.00); VD (3.70); ST (43.55 dynes/cm at 20°C); HC (130.2 J/Kmol at 298.15K); VP (<1 mm Hg at 20°C); OT (0.25ppm).

**CHEMICAL PROPERTIES:** Combustible; reacts vigorously with strong oxidizers, nitric acid and bases; FP (85°C); AT (482°C); LFL (1.5%).

**EXPOSURE ROUTES:** Inhalation (tobacco smoke); ingestion (food, especially kale, celery, carrots, peas and black tea); absorption; occupational exposure in industry using 2-methylaniline.

**HUMAN HEALTH RISKS:** Inhalation man T<sub>CLo</sub> 25 mg/m<sup>3</sup>; Acute Risks: irritation of skin, eyes, mucous membranes and upper respiratory tract; cyanosis; bluish discoloration of lips and tongue; death; Chronic Risks: methemoglobinemia; cyanosis; cancer of bladder, kidneys and blood; may alter genetic material.

**HAZARD RISK:** Combustible liquid and vapor; reacts with oxidizers, acids, bases; sealed containers may rupture under fire conditions; forms explosive vapor/air mixtures; NFPA Code: H 3; F 2; R 0.

**MEASUREMENT METHODS:** Silica gel; ethanol; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; R3; R4; R5; U328; C&Sf; Sf1; Sf3; A1; CAL.

**MAJOR USES:** Used in the production of ion exchange resins, dyes, rubber and blue-black textiles; reagent in glucose analysis; makes colors fast to acids.

**STORAGE:** Keep in a cool, dry, well-ventilated area away from heat, sunlight and oxidizing agents.

**FIRE FIGHTING:** Use dry chemical powder, appropriate foam, carbon dioxide or water spray.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (skin); OSHA PEL TWA 5 ppm (22 mg/m<sup>3</sup>)(skin); IDLH 50 ppm.

**PERSONAL PROTECTION:** Wear full protective clothing; wear chemical resistant gloves and chemical safety goggles; employ self-contained breathing apparatus; avoid inhalation of vapors, contact of liquid on skin, and ingestion.

**SPILL CLEAN-UP:** Use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; high-efficiency particulate arrestor or charcoal filters can be used to minimize amount of carcinogen in exhausted air; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (pallor, low-grade secondary anemia, fatigability, and loss of appetite); absorption (nausea, vomiting, coma, blue discoloration of lips, nails, and skin); contact (eye irritation, skin burns).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 670 mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove and discard clothing and wash skin; if inhaled remove to fresh air and provide artificial respiration and oxygen as needed; if ingested wash out mouth with water if victim is conscious and contact a physician.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 13; 14; 16.

### **TOXAPHENE (C<sub>10</sub>H<sub>10</sub>Cl<sub>8</sub>, 413.80)**

**CAS/DOT #:** 8001-35-2

**SYNONYMS:** Alltox, camphechlor, hercules 3956, motox, phenatox, toxakil, toxyphen.

**PHYSICAL PROPERTIES:** Yellow/amber waxy solid; turpentine-like odor; almost insoluble in water; miscible in aromatic hydrocarbons; MP (65-90°C, 149-194°F); DN (1.65 g/mL); VP (0.2-0.4mm Hg at 20°C); OT (0.14ppm).

**CHEMICAL PROPERTIES:** Dehydrochlorinates in presence of alkalis, exposure to sunlight, temperatures above 155°C; reacts with bases; AT (245°C); HC (-1036.8kcal/mol at 20°C).

**EXPOSURE ROUTES:** Inhalation (outdoor air); ingestion (contaminated fish, seafood and water); absorption; occupational exposure (farming and pesticide application).

**HUMAN HEALTH RISKS:** Oral human LDLo 28 mg/kg; skin human TDLo 657 mg/kg; EPA Group B2 probable human carcinogen; Acute Risks: irritation of skin; diarrhea; CNS stimulation; allergic skin dermatitis; vomiting; respiratory failure; somnolence; intermittent convulsions; seizures; coma; death; Chronic Risks: reversible respiratory toxicity; weight loss; loss of appetite; reversible deafness and disorientation.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat, flame, or oxidizers; explosive in vapor form when exposed to heat or flame; decomposition emits toxic fumes of NO<sub>x</sub>; NFPA Code: H 3; F 3; R 0.

**MEASUREMENT METHODS:** Bubbler; sodium hydroxide; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** CA2; S1; S24; S32; S50-b; S61; S62; R1; R3; R4; R5; R7; R8; D015; U123; C&Sf; Sf1; Sf3; CWA; CW1; CW2; CW3; CW4; CW5; CAL.

**MAJOR USES:** Pesticide used on cotton crops, peas, soybeans, corn, wheat, livestock and poultry; banned in 1982 by EPA except in emergencies and on banana and pineapple crops in Puerto Rico and the Virgin Islands.

**STORAGE:** Keep in a tightly closed container away from heat, sparks and open flame in a cool, dry place.

**FIRE FIGHTING:** Use extinguishing media suitable for surrounding fire.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup> (skin); ACGIH TLV STEL 1 mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.5 mg/m<sup>3</sup> (skin); NIOSH REL potential occupational carcinogen (skin); ISLH 200 mg/m<sup>3</sup> (potential occupational carcinogen).

**PERSONAL PROTECTION:** Wear impervious clothing, gloves, and face shields; wear chemical safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; for extra personal protection, a chemical protection suit including self-contained breathing apparatus is recommended.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable containers; use wet vacuuming or moisten first to prevent dusting; activated carbon and polyolefin or polyisobutylene fibers are recommended for use in the cleanup of mixtures including toxaphene.

**HEALTH SYMPTOMS:** Inhalation (respiratory failure, convulsions, dizziness, nausea, vomiting); skin adsorption (hyperexcitability, tremors, shivering, leg and back muscle spasms); eyes (redness); ingestion (nausea, vomiting, convulsions, dizziness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 50mg/kg; First aid: wash eyes immediately with large amounts of water; if skin contact occurs remove clothing and wash skin with large amounts of water and soap; if inhaled remove to fresh air and provide oxygen as needed; if inhaled drink water and induce vomiting.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 13; 14; 16.

**1,2,4-TRICHLOROBENZENE (C<sub>6</sub>H<sub>3</sub>Cl<sub>3</sub>, MW: 181.44)**

**CAS/DOT #:** 120-82-1/UN2321

**SYNONYMS:** Unsym-trichlorobenzene; 1,2,4-trichlorobenzol.

**PHYSICAL PROPERTIES:** Colorless liquid; aromatic odor; slightly soluble in water; miscible with ether, benzene, petroleum ether and carbon disulfide; volatile with steam; MP (16°C, 61°F); BP (214°C, 417°F); LSG (1.454); VD (>6); VP (1mm Hg at 38.4°C); OT (3ppm).

**CHEMICAL PROPERTIES:** Incompatible with strong oxidizers, acids and steam; FP (110°C, 230°F); LFL (2.4%); UFL (6.6%); AT (570°C).

**EXPOSURE ROUTES:** Inhalation; absorption through skin and eyes; ingestion (contaminated drinking water and contaminated food, especially fish); occupational exposure during manufacture and use.

**HUMAN HEALTH RISKS:** EPA Group D not classifiable as to human carcinogenicity; Acute Risks: irritation to eyes, mucous membranes, skin and respiratory tract; Chronic Risks: headaches; dizziness; nausea; gastrointestinal disturbances; liver and kidney damage.

**HAZARD RISK:** Combustible; upon combustion forms carbon monoxide, carbon dioxide, phosgene and hydrogen chloride gas; under fire conditions emits toxic fumes; NFPA Code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** Particulate filter; XAD tube; hexane; gas chromatography with electron capture detection.

**APPLICABLE REGULATIONS:** CA2; S32; S50-b; S61; S62; R3; R4; R5; R6; R9; C&Sf; Sfl; Sf3; CWA; CW4; CW5; T766-38; T799B; CAL.

**MAJOR USES:** Used in manufacture of herbicides; dye carrier; dielectric fluid in transformers; degreaser; lubricant; termite insecticide.

**STORAGE:** Keep away from strong oxidizers, acids, food and feedstuffs.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** Not available.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus (SCBA), rubber boots, heavy rubber gloves and other protective clothing;

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers or absorb with an inert material (e.g., dry earth, sand, vermiculite); flush re-

maintaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**HEALTH SYMPTOMS:** Not available.

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 756mg/kg; First aid: immediately wash eyes and skin with large amounts of water for at least 15 minutes; remove clothing if skin contact occurs; if inhaled remove to fresh air and give artificial respiration and oxygen as needed; if ingested wash out mouth with water if victim is conscious and call a physician.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 13; 14; 16.

### **1,1,2-TRICHLOROETHANE (C<sub>2</sub>H<sub>3</sub>Cl<sub>3</sub>, 133.4)**

**CAS/DOT #:** 79-00-5/UN2831

**SYNONYMS:** Ethane trichloride; beta-trichloroethane; vinyl trichloride

**PHYSICAL PROPERTIES:** Clear, colorless liquid; sweet, slightly irritating odor; almost insoluble in water; miscible with alcohols, ethers, esters, ketones and many other organic solvents; MP (-36.5°C, -33.7°F); BP (113.7°C, 236.7°F); LSG (1.435); VD (4.55); VP (18.8 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Polymerization will not occur; incompatible with strong bases and oxidizers; reacts violently with sodium, potassium, magnesium and aluminum; attacks some plastics, rubber, steel and zinc; nonflammable liquid; FP (not available); AT (460°C); LFL (8.4%); UFL (13.3%).

**EXPOSURE ROUTES:** Inhalation (atmosphere); absorption through skin and eyes; ingestion; occupational exposure during manufacture and use.

**HUMAN HEALTH RISKS:** EPA RfD 0.004mg/kg/day; Acute Risks: irritation of eyes, mucous membranes and respiratory tract; stinging, burning and whitening of skin; dizziness; drowsiness; nausea; headache; shortness of breath; unconsciousness; gastrointestinal irritation; liver, kidney and CNS effects; Chronic Risks: effects on liver, eyes, kidneys, cardiovascular system and immune system; mutagen; possible human carcinogen.

**HAZARD RISK:** Selectively combustible; heating will increase pressure which may cause bursting; vapor is heavier than air and may travel along the ground, then flash back; decomposition emits toxic fumes including hydrogen chloride gas, phosgene, carbon monoxide, and carbon dioxide; NFPA Code: H 2; F1; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatograph with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S1; S32; S50-b; S61; S62; S10; R2; R3; R4; R5; R7; R8; C&Sf; Sf1; Sf3; CWA; CW4; CW5; A1; CAL.

**MAJOR USES:** Used in manufacture of 1,1-dichloroethene; used as a solvent for chlorinated rubbers, oils, waxes, fats and resins; used in organic synthesis.

**STORAGE:** Keep in tightly closed container away from heat, sparks and flames in a cool, dry place.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers, but avoid direct contact with substance.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (55mg/m<sup>3</sup>)(skin); OSHA PEL TWA 10 ppm (45 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10 ppm (45 mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear boots, apron and chemical-resistant gloves; wear chemical safety goggles or a face shield; use positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** Use appropriate foam to blanket release and suppress vapors; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; any release in excess of 1 lb. should be reported; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (narcotic effects, irritates eyes, mucous membranes, and upper respiratory tract); skin absorption (stinging and burning sensations, whitening of the skin); ingestion (abdominal cramps, nausea, vomiting, diarrhea); contact (narcotic effects, dermatitis, severe eye irritant).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 836mg/kg; First aid: water rinse; drink milk; seek medical attention immediately.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 13; 14; 16.

## TRICHLOROETHYLENE (C<sub>2</sub>HCl<sub>3</sub>, 131.38)

**CAS/DOT #:** 79-01-6/UN1710

**SYNONYMS:** Allyl trichloride, ethylene trichloride, glycerol trichlorohydrin fluuate, trethylene, trichloran, trichloroethene, uestrosol.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; mobile; sweet chloroformic odor; insoluble in water; miscible with alcohol, ether, acetone and carbon tetrachloride; MP (-84°C, -119°F); BP (86.7°C, 188°F); DN (1.46 mg/L); VS (0.0055 P at 25°C); VD (4.53); VP (60 mm Hg at 20°C).

**CHEMICAL PROPERTIES:** Incompatible with oxidizers, chemically active metals and epoxies; decomposes slowly by light in presence of moisture; nonflammable; FP (32°C); AT (420°C); LFL (8.0%); UFL (10.5%).

**EXPOSURE ROUTES:** Inhalation (atmosphere, air around trichloroethylene plants and evaporation from waste disposal sites); absorption; ingestion (contaminated drinking water).

**HUMAN HEALTH RISKS:** Inhalation human TCLo 6900mg/m<sup>3</sup>; EPA Group B2 probable human carcinogen; Acute Risks: irritation of skin and eyes; sleepiness; confusion; inebriation; CNS effects; massive liver damage; cardiac arrhythmias; jaundice; kidney damage; Chronic Risks: weakness; confusion; headache; dizziness; CNS effects; cardiac failure; facial numbness; reproductive effects; increase in childhood leukemia.

**HAZARD RISK:** Generally nonflammable, but may combust under specific conditions; reacts with alkali and epoxides to form the spontaneously flammable gas dichloroacetylene;

forms HCl gas from reaction with water under heat and pressure; decomposition emits toxic fumes of Cl; NFPA Code: H 2; F 1; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S1; S32; S50-a; S61; S62; S10; R1; R3; R4; R5; R7; R8; R9; D040; U228; C&Sf; Sfl; Sf3; CWA; CW1; CW2; CW3; CW4; CW5; A1; A2; CAL.

**MAJOR USES:** Used in manufacture of paint removers, adhesives, typewriter correction fluid; refrigerant; degreaser of metal parts; used as an extraction solvent in greases, oils, fats, waxes, tars.

**STORAGE:** Keep in a tightly closed container away from heat, sparks and open flame in a cool, dry place; preferred containers sealed, dark ampules or frangible, dark glass tubes.

**FIRE FIGHTING:** Use water spray, dry chemical, carbon dioxide or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; ACGIH TLV STEL 200 ppm; OSHA PEL TWA 100 ppm; OSHA PEL CL 200 ppm; OSHA PEL 300ppm/5 M max peak/2H; NIOSH REL TWA 250 ppm; NIOSH REL CL (waste anesthetic gases) 2 ppm/1H; IDLH 1000 ppm.

**PERSONAL PROTECTION:** Wear neoprene or polyvinyl alcohol suit or aprons for splash protection; neoprene or polyvinyl-alcohol-type gloves and neoprene safety shoes are also recommended; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** Ventilate area of spill or leak; absorb as much as possible with non-combustible materials such as dry earth, sand or vermiculite; control runoff and dispose of properly.

**HEALTH SYMPTOMS:** Inhalation (eye effects, somnolence, hallucinations, headache, drowsiness, narcosis, anesthesia, jaundice, dizziness, difficult breathing, irritates eyes, nose and throat); ingestion (gastrointestinal disturbances, nausea, vomiting); contact (irritation or skin burns, irritation of mucous membranes, dermatitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5650mg/kg; First aid: rinse with water; remove to fresh air.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 13; 14; 16.

### 2,4,5-TRICHLOROPHENOL (C<sub>6</sub>H<sub>3</sub>Cl<sub>3</sub>O, 197.45)

**CAS/DOT #:** 95-95-4/UN2020

**SYNONYMS:** Collunosol, dowicide 2, dowicide B, nurelle, preventol-I, TCP.

**PHYSICAL PROPERTIES:** Gray flakes or needles; strong unpleasant phenolic odor; slightly soluble in water; miscible with ethyl ethers and weak acids; MP (-67°C, -89°F); BP (253°C, 487°F); DN (1.678mg/L at 230°C); VP (0.022 mm Hg at 25°C); OT (0.1ppm).

**CHEMICAL PROPERTIES:** Combustible; sublimes; nonflammable; weak acid; reacts with strong oxidizers; FP (0°C); AT (not available); LFL (not available); UFL (not available).

**EXPOSURE ROUTES:** Inhalation (incinerator emissions); absorption through skin and eyes; ingestion (contaminated food and drinking water); occupational exposure during manufacture and use of pesticides.

**HUMAN HEALTH RISKS:** EPA Group D inadequate data to determine carcinogenic class; Acute Risks: irritation of eyes, lungs and upper respiratory tract; headache; conjunctivitis; skin burns; weight loss; poisoning; cough; sore throat; blurred vision; diarrhea; sweating; abdominal pain; dizziness; nausea; vomiting; fatigue; Chronic Risks: dermatitis; effects on liver and kidneys.

**HAZARD RISK:** Fire hazard; combustible under specific conditions; decomposition spurred by contact with heat and/or strong oxidants emits toxic fumes of chlorine and hydrochloric acid; explodes upon heated decomposition; reacts under basic conditions and high temperatures to produce toxic chlorinated dioxins; NFPA Code: not available.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** F027.

**MAJOR USES:** Used in the manufacture of fungicides, bactericides, pesticides; used as a preservative in adhesives, synthetic textiles, rubber, wood, paints; antifungal agent; disinfection.

**STORAGE:** Keep away from strong oxidizers, food and feedstuffs.

**FIRE FIGHTING:** Use dry chemical powder, appropriate foam or carbon dioxide.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV) not established; Short Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) not established; IDLH not established.

**PERSONAL PROTECTION:** Wear complete protective clothing to prevent contact with skin, including chemical-resistant gloves; wear dust-proof safety goggles or face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; wear approved dust respirator for toxic dusts; for extra personal protection, self-contained breathing apparatus is recommended.

**SPILL CLEAN-UP:** Sweep spilled substance into scalable containers; if appropriate, moisten first in order to prevent dispersion of dust; collect remaining material, then remove to a safe place; ventilate area of spill safer clean-up is complete.

**HEALTH SYMPTOMS:** Inhalation (cough, sore throat, irritates nose and throat); skin (redness, dermatitis); eyes (redness, blurred vision, swelling of eyes); ingestion (dizziness, headache, sweating, fatigue, weakness, abdominal pain, vomiting, diarrhea).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 820mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs wash skin with large amounts of water; if inhaled remove to fresh air.

**KEY REFERENCES:** 2; 3; 5; 6; 7; 11; 13; 14; 16.

**2,4,6-TRICHLOROPHENOL (C<sub>6</sub>H<sub>3</sub>Cl<sub>3</sub>O, 197.45)****CAS/DOT #:** 88-06-2/UN2020**SYNONYMS:** Dovicide-25, omal, phenachlor, sym-trichlorophenol.**PHYSICAL PROPERTIES:** Yellow flakes; strong sweet odor; soluble in water, acetone, alcohol and ether; MP (69°C, 156°F); BP (245°C, 473°F); DN (1.49g/mL at 20°C); VP (1 mm Hg at 76.5°C); OT (0.0026ppm).**CHEMICAL PROPERTIES:** Non-flammable; will not polymerize; incompatible with strong oxidizers.**EXPOSURE ROUTES:** Primarily in water and wastewater; ingestion(contaminated food); pesticides; soil; wood; leather; glue preservatives; occupational exposure from production sources of chlorinated phenols or waste burners.**HUMAN HEALTH RISKS:** EPA Cancer Risk Level 0.0003mg/m<sup>3</sup> EPA Group B2 probable human carcinogen; Acute Risks: irritation of skin, eyes and upper respiratory tract; irritation of gastrointestinal tract; cough; diarrhea; corneal injury; nausea; vomiting; weakness; Chronic Risks: chronic bronchitis; altered pulmonary function; changes in liver and spleen cells; lower body weight; hepatic hyperplasia.**HAZARD RISK:** Gives off irritating fumes under fire conditions; combustion will produce carbon dioxide, carbon monoxide and hydrogen chloride; capable of creating dust explosions; reacts violently with strong oxidants; NFPA Code: not available.**MEASUREMENT METHODS:** Not available.**APPLICABLE REGULATIONS:** CAA; CA2; R3; R4; R5; R7; R8; R9; D042; F027; C&Sf; Sfl; Sf3; CWA; CW4; CW5; CAL.**MAJOR USES:** No longer used in the U.S.; previously used in manufacture of leather, pesticide for wood, glue preservation, anti-mildew treatment, fungicide, herbicide, defoliant.**STORAGE:** Keep in a well-ventilated area along the floor away from oxidizers, food and feedstuffs.**FIRE FIGHTING:** Use dry chemical powder, water spray, water mist or carbon dioxide.**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV) not established; Short Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) not established; IDLH not established.**PERSONAL PROTECTION:** Wear complete protective clothing to prevent contact with skin, including chemical-resistant gloves; wear dust-proof safety goggles or face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; wear approved dust respirator for toxic dusts; for extra personal protection, self-contained breathing apparatus is recommended.**SPILL CLEAN-UP:** Sweep spilled substance into scalable containers; if appropriate, moisten first in order to prevent dispersion of dust; collect remaining material, then remove to a safe place; ventilate area of spill safer clean-up is complete.

**HEALTH SYMPTOMS:** Inhalation (cough, sore throat, irritates nose and throat); skin (redness, dermatitis); eyes (redness, blurred vision, swelling of eyes); ingestion (dizziness, headache, sweating, fatigue, weakness, abdominal pain, vomiting, diarrhea).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 820mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash with large amounts of water; if inhaled remove to fresh air.

**KEY REFERENCES:** 2; 3; 5; 6; 7; 13; 14; 16; 17.

### TRIETHYLAMINE ((C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>N, 101.2)

**CAS/DOT #:** 121-44-8/UN1296

**SYNONYMS:** n,n-Diethylethanamine, TEA.

**PHYSICAL PROPERTIES:** Colorless liquid; ammonia-like odor; soluble in water; miscible with alcohol and chloroform; slightly soluble in benzene; MP (-115°C, -175°F); BP (89°C, 192°F); LSG (0.7); ST (20.7 dynes/cm); HV (140Btu/lb); VD (3.5); VP (400mm Hg at 31.5°C); OT (0.48ppm).

**CHEMICAL PROPERTIES:** Incompatible with strong acids, chlorine, hypochlorite, halogenated compounds and oxidizing agents; flammable; FP (-6°C); LFL (1.2%); UFL (8.0%); AT (245°C); HC (-1036.8kcal/mol at 20°C).

**EXPOSURE ROUTES:** Inhalation (emissions); absorption through skin and eyes; ingestion (contaminated food); occupational exposure during manufacture and use.

**HUMAN HEALTH RISKS:** Inhalation human TCLo 12mg/m<sup>3</sup>; Acute Risks: irritation of eyes, skin and mucous membranes; sneezing; coughing; nausea; pulmonary edema; systemic poisoning; skin, mouth, throat, stomach and eye burns; temporary vision loss; headache; labored breathing; diarrhea; severe abdominal pain; collapse; unconsciousness; Chronic Risks: reversible corneal edema; secondary skin burns; effects on heart, liver and kidneys.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat, flame or oxidizers; extremely flammable; closed containers exposed to heat may explode; vapor is heavier than air and may travel along the ground, then flash back; distant ignition is possible; explosive in vapor form when exposed to heat or flame; decomposition emits toxic fumes of nitrogen oxides; NFPA Code: H3; F3; R0.

**MEASUREMENT METHODS:** Bubbler; sodium hydroxide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; R4; U404; C&Sf; Sf1; Sf3; CWA; CW1; CW2; A1; CAL.

**MAJOR USES:** Catalytic solvent in chemical synthesis; accelerator for rubber; corrosion inhibitor; curing and hardening agent for polymers; manufacture of wetting, penetrating and waterproofing agents; desalination of seawater; preparation of emulsifiers for pesticides.

**STORAGE:** Keep in a tightly closed container away from heat, sparks and open flame in a cool, dry place.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers; fight fire from protected location.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm; ACGIH TLV STEL 15 ppm; OSHA PEL TWA 25ppm (100 mg/m<sup>3</sup>); IDLH 200ppm.

**PERSONAL PROTECTION:** Wear rubber overclothing including rubber gloves; wear chemical safety goggles or face shield; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** Use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in a fume hood; absorb large quantities in noncombustible materials and atomize in a suitable combustion chamber equipped with afterburner and appropriate effluent gas cleaning device; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (coughing, choking, difficult breathing, loss of consciousness, irritates eyes, nose and throat); contact (severe skin and eye burns); ingestion (nausea, vomiting, convulsions).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 460mg/kg; First aid: rinse with water and remove to fresh air.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 12; 13; 14; 16.

### **TRIFLURALIN (C<sub>13</sub>H<sub>16</sub>F<sub>3</sub>N<sub>3</sub>O<sub>4</sub>, 335.3)**

**CAS/DOT #:** 1582-09-8/UN not available

**SYNONYMS:** 2,6-Dinitro-n,n-di-n-propyl-alpha-alpha-alpha-trifluoro-p-toluidine, alpha, alpha, alpha-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine, agreflan, treflan.

**PHYSICAL PROPERTIES:** Orange crystals; odorless; slightly soluble in water; miscible with xylene; MP (49°C, 120°F); BP (140°C, 284°F); DN (not available); VP (1.99E-04 mm Hg at 29.5°C).

**CHEMICAL PROPERTIES:** Stable; decomposes upon heating or burning.

**EXPOSURE ROUTES:** Inhalation (plant emissions and herbicide); absorption through skin and eyes (farm workers); ingestion (contaminated fish, agricultural products and agricultural runoff in surface water).

**HUMAN HEALTH RISKS:** EPA RfD 0.0075mg/kg/day; EPA Group C possible human carcinogen; Acute Risks: irritation of eyes, skin and respiratory tract; CNS effects; weakness; Chronic Risks: skin sensitization; insufficient human information available concerning long-term exposure.

**HAZARD RISK:** Combustible under certain conditions; mixtures with organic solvents present explosion hazard; decomposition emits toxic fumes of hydrogen fluoride and nitrogen oxides; NFPA Code: not available

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; S1; FIFRA; C&Sf; Sf3; CAL.

**MAJOR USES:** Used as a herbicide for annual grasses, broad leaf annual weeds, crops, shrubs, flowers and cotton.

**STORAGE:** Keep upwind, with necessary provision to contain effluent from fire extinguishing.

**FIRE FIGHTING:** Not available.

**EXPOSURE GUIDELINES:** Threshold Limit Value (TLV) not established; Short Term Exposure Limit (STEL) not established; Permissible Exposure Limit (PEL) not established; Recommended Exposure Limit (REL) not established; IDLH not established.

**PERSONAL PROTECTION:** Wear gas tight suit and compressed air/oxygen apparatus; protective gloves are required; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus; for extra personal protection, use a P2 filter respirator for harmful particles.

**SPILL CLEAN-UP:** Sweep spilled substance into sealable containers; moisten first to prevent dusting; collect remaining material, then remove to safe place; do not wash away into sewer; ventilate area of spill after clean-up is complete.

**HEALTH SYMPTOMS:** Inhalation (irritates eyes, skin, and upper respiratory tract); eyes (redness, pain, lacrimation); skin (skin sensitization); ingestion (burning sensation, weakness).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 1930mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs wash skin with water.

**KEY REFERENCES:** 3; 5; 6; 7; 13; 14; 16.

## **2,2,4 TRIMETHYLPENTANE (C<sub>8</sub>H<sub>18</sub>, 114.26)**

**CAS/DOT #:** 540-84-1/UN1262

**SYNONYMS:** Isobutyl-trimethylmethane, isooctane trimethylpentane.

**PHYSICAL PROPERTIES:** Clear liquid; odor of gasoline; insoluble in water; MP (-116°C, -177°F); BP (99.2°C, 211°F); DN (0.692 g/mL at 20°C); VD (3.93); VP (40.6 mm Hg at 21°C).

**CHEMICAL PROPERTIES:** Stable under normal use conditions; hazardous polymerization will not occur; incompatible with oxidizers, reducing agents, acids and bases; FP (-12.2°C); LFL (1.1%); UFL (6.0%); AT (779°F).

**EXPOSURE ROUTES:** Inhalation (atmosphere, petroleum refining and vehicle emissions); absorption through skin and eyes; occupational exposure during manufacture, use, and disposal of products in petroleum and gasoline field.

**HUMAN HEALTH RISKS:** Acute risks: necrosis of skin and tissue; irritation of lungs; hemorrhage; CNS depression; unconsciousness; nausea and vomiting; dizziness; headache; blisters; irritation of skin and eyes; lack of coordination; respiratory arrest; ventricular fibrillation; bronchial pneumonia; bloody sputum; high fever; convulsions; Chronic Risks: dermatitis; CNS depression.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat, flame or oxidizers; reacts vigorously with reducing materials; explosive with air when in vapor form when exposed to heat or flame; decomposition emits acrid smoke and irritating fumes; vapor is heavier than air and may travel along the ground, then flash back; distant ignition is possible; may cause flash fires; formation of corrosive vapors; may generate electrostatic charges; NFPA Code: H not available; F 3; R 0.

**MEASUREMENT METHODS:** Not available.

**APPLICABLE REGULATIONS:** CAA; CA2; CAL.

**MAJOR USES:** Used in manufacture of solvents and thinners; organic synthesis; anti-knock agent; spectrophotometric analysis; determination of octane numbers of fuels; azeotropic distillation entrainer.

**STORAGE:** Keep in a flammable liquid storage room in a cool, dry, well-ventilated location; outside or detached storage is preferred.

**FIRE FIGHTING:** Use dry chemical powder, appropriate foam or carbon dioxide; water may be ineffective; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** Threshold Limit Value no information found; OSHA PEL TWA 500 ppm (Petroleum Distillates); NIOSH REL TWA 350 mg/m<sup>3</sup>; NIOSH REL CL 1800 mg/m<sup>3</sup> (Refined Petroleum Distillates).

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use non-sparking type tools and equipment, including explosion proof ventilation; wear self-contained breathing apparatus in oxygen-deficient atmospheres; provide eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** Use water spray to disperse vapors and to flush spills away from exposures; collect liquid in an appropriate container or absorb with sand or other inert material, and place in a chemical waste container; remove all sources of ignition; ventilate area of spill after clean-up is complete.

**HEALTH SYMPTOMS:** Inhalation (dizziness, lack of coordination, narcosis, respiratory arrest); skin (prickling, redness, blisters, allergic dermatitis); eyes (redness, itching, pain); ingestion (nausea, vomiting, edema, bloody sputum, pulmonary irritation, shallow respiration, unconsciousness, convulsions, bronchial pneumonia, fever, coughing, ventricular fibrillation, kidney, liver and bone damage).

**GENERAL COMMENTS:** First aid: wash eyes and skin with water; provide respiratory support.

**KEY REFERENCES:** 2; 5; 6; 7; 13; 14; 16.

**VINYL ACETATE (C<sub>4</sub>H<sub>6</sub>O<sub>2</sub>, 86.09)**

**CAS/DOT #:** 108-05-4/UN1301

**SYNONYMS:** Acetic acid ethenyl ester, 1-acetoxyethylene, ethenyl acetate, ethenyl ethanoate, VAC.

**PHYSICAL PROPERTIES:** Clear, colorless liquid; pleasant, fruity odor; slightly soluble in water; miscible with alcohol and ether; MP (-93°C, 256°F); BP (72.7°C, 163°F); DN (0.932g/mL at 20°C); LSG (0.93); ST 24.0 dynes/cm); VS (0.42 mP at 20°C); VD (3.0); VP (115 mm Hg at 25°C); HV (163 Btu/lb); OT (0.5ppm).

**CHEMICAL PROPERTIES:** Polymerizes to solid in light; usually contains a polymerization prohibitor such as hydroquinone or diphenylamine; incompatible with acids, bases, silica gel, alumina, oxidizers, peroxides, ozone, 2-amino ethanol, chlorosulfonic acid, ethylene-diamine and heat; FP (-8°C); LFL (2.6%); UFL (13.4%); AT (426°C); HC (-9754 Btu/lb).

**EXPOSURE ROUTES:** Inhalation (ambient air near manufacturing facilities); occupational exposure during manufacture or use.

**HUMAN HEALTH RISKS:** EPA Group C possible human carcinogen; Acute Risks: irritation of eyes, skin and upper respiratory system; loss of smell; eye burns; skin blisters; lung damage; drowsiness; headache; convulsions; narcosis; Chronic Risks: upper respiratory tract irritation; cough and hoarseness.

**HAZARD RISK:** Highly dangerous fire hazard when exposed to heat, flame or oxidizers; may undergo spontaneous exothermic polymerization; reaction with air or water to form peroxides that form explosions; reacts with ozone to form explosive vinyl acetate ozonide; vapor may react vigorously with desiccants; NFPA Code: H 2; F 3; R 2.

**MEASUREMENT METHODS:** Chromosorb tube; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; R2; R3; C&Sf; Sf1; Sf3; CWA; CW1; CW2; T120-a; A1; CAL.

**MAJOR USES:** Used in manufacture of plastic masses, films, lacquers, emulsion paint substances, glue, adhesives, paper coatings, water-based paints, inks, hairsprays and chewing gum.

**STORAGE:** Keep in a container away from heat, sparks and open flame; refrigerate.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (35 mg/m<sup>3</sup>); ACGIH TLV STEL 15 ppm (53 mg/m<sup>3</sup>); OSHA PEL none; NIOSH REL CL 4 ppm (15 mg/m<sup>3</sup>); IDLH not determined.

**PERSONAL PROTECTION:** Wear impervious outerwear, including boots, rubber or plastic gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment and lighting; for extra personal protection, wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** Collect leaking liquid in sealable containers or absorb in sand or other inert absorbent; absorb bulk liquid with fly ash, cement powder, or sawdust, first applying gelling agent to immobilize spill; apply fluorocarbon-water foam to diminish vapor.

**HEALTH SYMPTOMS:** Inhalation (dizziness, difficult breathing, shortness of breath, cough, sore throat, narcosis, irritates eyes, skin and respiratory tract); eyes (redness, pain, minor burns); skin (redness, blisters); ingestion (drowsiness, headache, tissue lesions).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 2920mg/kg; First aid: rinse with water; remove to fresh air and give respiratory support.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 12; 13; 14; 16.

### **VINYL BROMIDE (C<sub>2</sub>H<sub>3</sub>Br, 106.96)**

**CAS/DOT #:** 593-60-2/UN1085

**SYNONYMS:** Bromoethene, bromoethylene.

**PHYSICAL PROPERTIES:** Colorless gas or liquid (below 60°F); pleasant odor; slightly soluble in water; miscible with alcohol and ether; MP (-139.5°C, -219°F); BP (15.6°C, 60°F); DN (1.47g/mL at 20°C); LSG (1.49); ST (22.54mN/m at 20°C); VD (3.8); VP (1033 mm Hg at 25°C).

**CHEMICAL PROPERTIES:** Polymerizes in sunlight; incompatible with copper, alloys, plastics and oxidizing agents; FP (5°C); LFL (9%); UFL (15%); AT (986°C).

**EXPOSURE ROUTES:** Inhalation; ingestion; absorption; occupational exposure during manufacture or use of vinyl bromide.

**HUMAN HEALTH RISKS:** EPA Group B2 probable human carcinogen; Acute Risks: irritation of eyes and skin; dizziness, nausea; vomiting; disorientation; confusion; loss of coordination; frostbite; sleepiness; narcosis; Chronic Risks: liver damage; CNS disorders; effects on eyes and skin.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat or flame; hazardous decomposition products include carbon monoxide, carbon dioxide and hydrogen bromide gas; NFPA Code: H 2; F 0; R 1.

**MEASUREMENT METHODS:** Charcoal tube; ethanol; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; A1; CAL.

**MAJOR USES:** Used in manufacture of flame retardant synthetic fibers, preparing films, laminating fibers, rubber substitutes, sleepwear, home furnishings, leather, fabricated metal products and plastics.

**STORAGE:** Keep in a tightly closed container away from heat, sparks, or flame.

**FIRE FIGHTING:** Use carbon dioxide water spray or dry chemical powder.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (22 mg/m<sup>3</sup>); OSHA PEL none; NIOSH REL lowest detectable level, potential occupational carcinogen; IDLH not determined, potential occupational carcinogen.

**PERSONAL PROTECTION:** Wear protective suits (one-piece, close-fitting at ankles and wrists, and disposable), gloves, overshoes, and hair covering; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** Use a high-efficiency particulate arrestor (HEPA) to minimize amount of carcinogen; transfer used filters into sealable plastic bags; pour waste liquids onto vermiculite, sodium bicarbonate, or sand-soda ash mixture and place in secured containers for proper disposal.

**HEALTH SYMPTOMS:** Inhalation (dizziness, irritates eyes, skin and upper respiratory tract); skin (liquid may cause frostbite); ingestion (nausea, vomiting, confusion, in coordination).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 500mg/kg; First aid: immediately wash eyes with large amounts of water; if skin contact occurs remove clothing and wash with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested wash out mouth with water as long as victim is conscious.

**KEY REFERENCES:** 2; 4; 5; 6; 7; 10; 12; 13; 14; 16.

## VINYL CHLORIDE (C<sub>2</sub>H<sub>3</sub>Cl, 62.50)

**CAS/DOT #:** 75-01-4/UN1086

**SYNONYMS:** Chloroethene, chloroethylene, ethylene monochloride, VC.

**PHYSICAL PROPERTIES:** Colorless gas or liquid (below 7°F); pleasant odor; slightly soluble in water; miscible with alcohol, ether, carbon tetrachloride and benzene; MP (-154°C, -245°F); BP (-11°C, 7°F); DN (0.91g/mL at 20°C); LSG (0.9); VD (2.15); VP (2600 mm Hg at 25°C); OT (3000ppm).

**CHEMICAL PROPERTIES:** Polymerizes; incompatible with copper, aluminum, peroxides, iron, steel and oxidizing agents; attacks iron and steel in presence of water; FP (-78°C, -112°F); LFL (3.6%); UFL (33.0%); AT (472°C).

**EXPOSURE ROUTES:** Inhalation (atmosphere, emissions and air inside new cars); absorption through skin and eyes; ingestion (contaminated drinking water, water in contact with polyvinyl pipes and microbial degradation of product of trichloroethylene in groundwater).

**HUMAN HEALTH RISKS:** Inhalation human TCLo 30mg/m<sup>3</sup>; EPA Group A human carcinogen; Acute Risks: irritation to eyes and upper respiratory tract; CNS effects; dizziness; drowsiness; headache; weakness; abdominal pain; gastrointestinal bleeding; frostbite; enlarged liver; unconsciousness; Chronic Risks: liver damage; blood disorders; "vinyl chloride disease"; lung effects; poor circulation in fingers; cancer of the brain, lung, liver and digestive tract.

**HAZARD RISK:** Extremely flammable; explosive in air/gas mixtures; combustion produces toxic and corrosive fumes including hydrogen peroxide and phosgene; explosive polymerization from its peroxides; large fires of this material are practically inextinguishable; NFPA Code: H 2; F 4; R 2.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; S1; S32; S50-a; S61; S62; R2; R3; R4; R5; R7; R8; D043; U043; C&Sf; Sf1; Sf3; CWA; CW3; CW4; CW5; A1; CAL.

**MAJOR USES:** Used in manufacture of polyvinyl chloride, plastics, vinyl products and refrigerant gas.

**STORAGE:** Keep in a container away from heat, sparks and open flame in a cool, dry place.

**FIRE FIGHTING:** Use dry chemical powder or carbon dioxide; stop flow of gas immediately; if possible, allow fire to burn itself out; use water to cool exposed containers; fight fire from a protected position.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; ACGIH TLV STEL 25.6 mg/m<sup>3</sup>; OSHA PEL TWA 1 ppm; OSHA PEL CL 5 ppm (12.8 mg/m<sup>3</sup>); NIOSH REL lowest detectable level.

**PERSONAL PROTECTION:** wear rubber boots, apron and chemical-resistant gloves; wear positive pressure self-contained breathing apparatus equipped with full face piece; wear chemical safety goggles.

**SPILL CLEAN-UP:** use water spray to cool or disperse vapors; absorb liquid with non-combustible materials (e.g. dry earth, sand or vermiculite), and place in chemical waste containers; remove all sources of ignition.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, giddiness, irritation to eyes, irritation to upper respiratory tract, and skin burns); contact (liquid causes frostbite damage).

**GENERAL COMMENTS:** Original NESHAP; oral rat LD<sub>50</sub> 500mg/kg; First aid: rinse with water and remove to fresh air.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 13; 14; 16.

### VINYLDENE CHLORIDE (C<sub>2</sub>H<sub>2</sub>Cl<sub>2</sub>, 96.94)

**CAS/DOT #:** 75-35-4/UN1303

**SYNONYMS:** 1,1-Dichloroethene, 1,1-dichloroethylene, VDC, vinylidene dichloride.

**PHYSICAL PROPERTIES:** Colorless liquid; mild, sweet odor; negligible solubility in water; miscible with organic solvents; MP (-122.5°C, -188.5°F); BP (31.7°C, 89.1°F); DN (1.21g/mL at 20°C); LSG (1.21); VD (3.5); VP (591 mm Hg at 25°C); OT (190ppm).

**CHEMICAL PROPERTIES:** Will polymerize to plastic when in contact with oxidizers, chlorosulfonic acid, nitric acid or oleum; flammable liquid; often contains polymerization inhibitors such as hydroquinone ethers; incompatible with oxidizing agents, peroxides, aluminum, copper, sunlight, heat and air; FP (-15°C); LFL (6.5%); UFL (15.5%); AT (519°C).

**EXPOSURE ROUTES:** Inhalation (atmosphere and emissions); absorption through skin and eyes; ingestion (contaminated drinking water); occupational exposure.

**HUMAN HEALTH RISKS:** Inhalation human TCl<sub>0</sub> 25ppm; ; EPA Group C: possible human carcinogen; Acute Risks: irritation to eyes, skin and respiratory system; adverse neuro-

logical effects; CNS depression; inebriation; dyspnea; dizziness; headache; abdominal pain; sore throat; skin burns; chemical pneumonitis; convulsions; unconsciousness; Chronic Risks dermatitis; liver and kidney injury; lung effects; gastrointestinal effects; cardiovascular effects; neurological effects.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat or flame; moderately explosive in the vapor form when exposed to heat or flame; forms explosive peroxides when exposed to air; can explode spontaneously; reaction with ozone forms dangerous products; decomposition emits toxic fumes of hydrogen chloride, chlorine and phosgene; NFPA Code: H 4; F 4; R 2.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; R2; R3; C&Sf; Sf1; Sf3; CWA; CW1; CW2; CAL.

**MAJOR USES:** Used in the manufacture of polyvinylidene chloride copolymers, flexible films for food packaging, flame retardant coatings and adhesive applications.

**STORAGE:** Keep in a tightly closed container away from heat, sparks, or open flame; handle with care.

**FIRE FIGHTING:** Use carbon dioxide, dry chemical powder or appropriate foam; use water spray to cool exposed containers; fight fire from protected position.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (20 mg/m<sup>3</sup>); ACGIH TLV STEL 20 ppm (79 mg/m<sup>3</sup>) OSHA PEL none; NIOSH REL TWA reduce to lowest detectable level, potential occupational carcinogen; IDLH not determined, potential occupational carcinogen.

**PERSONAL PROTECTION:** Wear impervious outerwear, including boots, protective gloves, lab coat, apron or coveralls; wear chemical safety goggles in combination with breathing protection; enclose operations and/or use local exhaust ventilation at site of chemical release; use non-sparking handtools, explosion-proof electrical equipment and lighting; for extra personal protection, self-contained breathing apparatus is recommended.

**SPILL CLEAN-UP:** Evacuate danger area; collect spilled liquid in sealable containers or absorb in sand or inert absorbent and remove to safe place.

**HEALTH SYMPTOMS:** Inhalation (dizziness, drowsiness, difficult breathing, loss of consciousness, irritates eyes, skin and throat); skin (redness, skin burns, dermatitis); eyes (redness, pain); ingestion (abdominal pain, nausea, sore throat, chemical pneumonitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 200mg/kg; First aid: rinse with water; fresh air.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 13; 14; 16.

**XYLENES (C<sub>6</sub>H<sub>4</sub>(CH<sub>3</sub>)<sub>2</sub>, 106.18)**

**CAS/DOT #:** 1330-20-7/UN1307

**SYNONYMS:** Benzene, dimethyl-benzene, methyl toluene, xylol.

**PHYSICAL PROPERTIES:** Colorless liquid; sweet odor; insoluble in water; miscible with alcohol, ether and other organic solvents; MP (-47.4°C, -53.3°F); BP (137-140°C, 279-284°F); DN (0.864g/mL at 20°C); LSG (0.86); VD (3.7); VP (18mm Hg at 37.7°C); OT (5.0E-05ppm)

**CHEMICAL PROPERTIES:** Will not polymerize; incompatible with oxidizing agents; corrosive to some forms of plastic and rubber; easily chlorinated, nitrated and sulfonated; FP (29°C); LFL (1.1%); UFL (7.0%); AT (464°C).

**EXPOSURE ROUTES:** Inhalation (atmosphere, paints, air near filling stations and emissions from heavy traffic); absorption through skin and eyes; ingestion (contaminated drinking water); occupational hazard in industries that use xylene in manufacturing.

**HUMAN HEALTH RISKS:** Acute Risks: irritation of eyes, mucous membranes, lungs and upper respiratory tract; pulmonary edema; CNS depression; chest pain; gastrointestinal difficulties; dermatitis; nausea; vomiting; salivation; corneal burns; Chronic Risks: loss of appetite; liver, kidney and nerve damage; memory loss; chronic bronchitis; ringing in the ears; excessive fatigue.

**HAZARD RISK:** Dangerous fire hazard; container may explode during a fire; vapor can travel long distances to the source of ignition and flash back; forms explosive mixtures in air; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** : Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; R2; R6; R5; C&Sf; Sf1; Sf3; S1; S32; S10; CWA; CW1; CW2; A1; CAL.

**MAJOR USES:** Manufacture of dyes, varnishes, resins, ethyl benzene, benzoic acid, hydrogen peroxide, terphthalic acids, organic chemicals, paint, polyester fibers, solvents, perfumes, insect repellents and pharmaceuticals.

**STORAGE:** Keep containers tightly closed and store in a cool, dry area.

**FIRE FIGHTING:** Use dry chemical powder, carbon dioxide or appropriate foam.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; ACGIH TLV STEL 150 ppm; OSHA PEL TWA 100 ppm; NIOSH REL CL 200 ppm/10 min; IDLH 1000 ppm.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; use non-sparking type tools and equipment, including explosion proof ventilation; appropriate respirators are needed in areas where the exposure limit is exceeded; wear self-contained breathing apparatus in oxygen-deficient atmospheres.

**SPILL CLEAN-UP:** Use water spray to disperse vapors and the flush spills away from exposures; collect liquid in an appropriate container or absorb with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; ventilate area of spill after clean-up is complete; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates nose and throat, headache, severe breathing difficulties, cough, hoarseness, ringing in ears, anesthesia, nausea, vomiting); skin (loss of natural oils, dermatitis); eyes (severe irritation, possible corneal burns, eye damage); ingestion (nausea, vomiting, salivation, burning sensation in mouth and stomach, severe hemorrhagic pneumonitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 4300 mg/kg; First aid: immediately wash eyes with water; flush skin with water; remove clothing; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested wash mouth with water if victim is conscious.

**KEY REFERENCES:** 5; 6; 10; 12; 13; 14; 16.

### **o-XYLENE (C<sub>6</sub>H<sub>4</sub>(CH<sub>3</sub>)<sub>2</sub>, 106.18)**

**CAS/DOT #:** 95-47-6/UN1307

**SYNONYMS:** Benzene, dimethyl-benzene, methyl toluene, xylol.

**PHYSICAL PROPERTIES:** Colorless liquid; sweet aromatic odor; vapor is heavier than air; insoluble in water; miscible with alcohols and ether; MP (-25°C, -13°F); BP (144°C, 291.2°F); DN (0.88 g/mL at 20°C); LSG (0.88); ST (30.1 dynes/cm); VS (0.810 cP at 20°C); VD (3.7); VP (7 mm Hg at 20°C); OT (0.05-1.8 ppm).

**CHEMICAL PROPERTIES:** Will not polymerize; incompatible with oxidizing agents and strong acids; FP (17°C); LFL (1.1%); UFL (7.0%); AT (527°C); HC (1091.7 kg/cal).

**EXPOSURE ROUTES:** Inhalation (atmosphere and paints); absorption through skin and eyes; ingestion (contaminated drinking water).

**HUMAN HEALTH RISKS:** EPA RfD 2mg/kg/d; Acute Risks: irritating to skin, eyes and respiratory system; narcotic in high concentrations; CNS depression; dermatitis; hemorrhagic pneumonitis; nausea; vomiting; salivation; ringing in the ears; severe breathing difficulty; gastrointestinal disturbances; Chronic Risks: pulmonary damage; hemorrhage; bone marrow damage; low blood cell count; loss of appetite; reversible eye damage; may impair fertility; liver damage; kidney damage.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat or flame; can react with oxidizing materials; explosive in vapor form when exposed to heat or flame; decomposition emits acrid smoke and irritating fumes including carbon monoxide and unidentified organic compounds; NFPA Code: H2, F3, R0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; S1; S32; S10; FIFRA; CWA; CW1; CW2; A1; CAL.

**MAJOR USES:** Manufacture of diphthalic anhydride, phthalic anhydride, phthalonitrile, benzoic acid, ethyl benzene, high performance polymers, plasticizers, alkyd resins, glass reinforced polyesters, dyes, insecticides and motor fuels.

**STORAGE:** Keep under nitrogen in a cool, dry, well-ventilated area.

**FIRE FIGHTING:** Use dry chemical powder, appropriate foam or carbon dioxide; use water spray to cool containers exposed to fire; use water spray to dilute mixtures to nonflammable solutions.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; ACGIH TLV STEL 150 ppm; OSHA PEL TWA 100 ppm; NIOSH REL CL 200 ppm/10 min; IDLH 1000 ppm.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; use non-sparking type tools and equipment, including explosion proof ventilation; appropriate respirators are needed in areas where the exposure limit is exceeded; wear self-contained breathing apparatus in oxygen-deficient atmospheres.

**SPILL CLEAN-UP:** Use water spray to disperse vapors and the flush spills away from exposures; collect liquid in an appropriate container or absorb with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; ventilate area of spill after clean-up is complete; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates nose and throat, headache, severe breathing difficulties, cough, hoarseness, ringing in ears, anesthesia, nausea, vomiting); skin (loss of natural oils, dermatitis); eyes (severe irritation, possible corneal burns, eye damage); ingestion (nausea, vomiting, salivation, burning sensation in mouth and stomach, severe hemorrhagic pneumonitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5g/kg; First aid: rinse with water; remove to fresh air.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 12; 13; 14; 16.

### **m-XYLENE (C<sub>6</sub>H<sub>4</sub>(CH<sub>3</sub>)<sub>2</sub>, 106.18)**

**CAS/DOT #:** 108-38-3

**SYNONYMS:** Benzene, dimethyl-benzene, methyl toluene, xylol.

**PHYSICAL PROPERTIES:** Colorless liquid; sweet odor; insoluble in water; miscible with alcohol, ether and other organic solvents; MP (-47.4°C, -53.3°F); BP (139.3°C, 282.7°F); DN (0.867g/mL at 15°C); LSG (0.87); VD (3.7); VP (10mm Hg at 28.3°C); OT (1.1ppm).

**CHEMICAL PROPERTIES:** Hazardous polymerization will not occur; stable under normal use conditions; incompatible with oxidizing agents and strong acids; FP (25°C); LFL (1.1%); UFL (7.0%); AT (527°C).

**EXPOSURE ROUTES:** Inhalation (atmosphere and paints); absorption through skin and eyes; ingestion (contaminated drinking water); production and use of mixed xylenes.

**HUMAN HEALTH RISKS:** EPA Group D non-human carcinogen; Acute Risks: disturbed vision; corneal damage; anorexia; nausea; vomiting; dizziness; abdominal pain; incoherence; excitement; flushing of face; dizziness; tremors; stagger; CNS depression; coma; Chronic Risks: skin defatting; headache; dizziness; fatigue; respiratory irritation; memory loss; anemia; vertigo; pneumonia; reduced learning rate and ability.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat or flame; can react with oxidizing materials resulting in fire; explosive in vapor form when exposed to heat or flame; decomposition emits acrid smoke and irritating fumes including carbon monoxide and unidentified organic compounds; NFPA Code: H 2; F 3; R 0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; T120-a; CAL.

**MAJOR USES:** Used in the production of benzoic acid, phthalic anhydride, isophthalic and terphthalic acids, polyester fibers, solvents, dyes and paints and coatings; clearing agent in microscopic technique; blended into gasoline.

**STORAGE:** Keep in a tightly closed container away from heat, sparks, strong oxidizers, strong acids and open flame; store in a cool, dry, well-ventilated place.

**FIRE FIGHTING:** Use appropriate foam, carbon dioxide or dry chemical powder; use water spray to cool exposed containers; use water to dilute mixtures to nonflammable solutions.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; ACGIH TLV STEL 150 ppm; OSHA PEL TWA 100 ppm; NIOSH REL CL 200 ppm/10 min; IDLH 1000 ppm.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; use non-sparking type tools and equipment, including explosion proof ventilation; appropriate respirators are needed in areas where the exposure limit is exceeded; wear self-contained breathing apparatus in oxygen-deficient atmospheres.

**SPILL CLEAN-UP:** Use water spray to disperse vapors and the flush spills away from exposures; collect liquid in an appropriate container or absorb with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; ventilate area of spill after clean-up is complete; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates nose and throat, headache, severe breathing difficulties, cough, hoarseness, ringing in ears, anesthesia, nausea, vomiting); skin (loss of natural oils, dermatitis); eyes (severe irritation, possible corneal burns, eye damage); ingestion (nausea, vomiting, salivation, burning sensation in mouth and stomach, severe hemorrhagic pneumonitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5g/kg; First aid: immediately wash eyes and skin with large amounts of water; if inhaled remove to fresh air and provide respiratory apparatus as needed; if ingested rinse mouth with water if victim is conscious.

**KEY REFERENCES:** 2; 3; 5; 6; 7; 10; 13; 14; 16.

**p-XYLENE (C<sub>6</sub>H<sub>4</sub>(CH<sub>3</sub>)<sub>2</sub>, 106.18)**

**CAS/DOT #:** 106-42-3/UN1307

**SYNONYMS:** Benzene, dimethyl-benzene, methyl toluene, xylol.

**PHYSICAL PROPERTIES:** Colorless plates, prisms or liquid; sweet odor; negligible solubility in water; miscible with alcohol, ether and other organic liquids; MP (13.3°C, 55.9°F); BP (137-140°C, 279-284°F); DN (0.86g/mL at 20°C); LSG (0.88); ST (28.3 dynes/cm); VS (0.648 cP at 20°C); VD (3.66); VP (10 mm Hg at 27.3°C); OT (1.1 ppm).

**CHEMICAL PROPERTIES:** Hazardous polymerization will not occur; incompatible with strong oxidizers, strong acids and dichlorohydroantoin; attacks some plastic and rubber compounds; FP (27.2°C); LFL (1.1%); UFL (7.0%); AT (528°C).

**EXPOSURE ROUTES:** Inhalation (atmosphere and paints); absorption through skin and eyes; ingestion (contaminated drinking water); production and use of mixed xylenes.

**HUMAN HEALTH RISKS:** EPA Group D non-human carcinogen; Acute Risks: disturbed vision; excitement; incoherence; drowsiness; corneal damage; anorexia; nausea; vomiting; abdominal pain; dermatitis; flushing of face; dizziness; tremors; stagger; CNS depression; coma; Chronic Risks: headache; dizziness; fatigue; respiratory irritation; memory loss; anemia; vertigo; pneumonia; effects on eyes, skin, respiratory system, CNS, gastrointestinal tract, blood, liver and kidneys.

**HAZARD RISK:** Very dangerous fire hazard when exposed to heat or flame; can react with oxidizing materials; explosive in vapor form when exposed to heat or flame; decomposition emits acid smoke and irritating fumes; NFPA Code: H 2; F 3; R0.

**MEASUREMENT METHODS:** Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection.

**APPLICABLE REGULATIONS:** CAA; CA2; C&Sf; Sf1; Sf3; T30-e; T120-a; T120-10; CAL.

**MAJOR USES:** Used in production of benzoic acid, phthalic anhydride, isophthalic and terephthalic acids, polyester fibers, solvents, dyes, paints and coating and insecticides; clearing agent in microscopic technique; blended into gasoline; pharmaceutical synthesis.

**STORAGE:** Keep stored in a tightly closed container away from heat, flame and sources of ignition in a cool, dry, well-ventilated area; outside or detached storage preferred.

**FIRE FIGHTING:** Use appropriate foam, carbon dioxide or dry chemical powder; use water spray to cool exposed containers; use water to dilute mixtures into nonflammable solutions.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; ACGIH TLV STEL 150 ppm; OSHA PEL TWA 100 ppm; NIOSH REL CL 200 ppm/10 min; IDLH 1000 ppm.

**PERSONAL PROTECTION:** Wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; use non-sparking type tools and equipment, including explosion proof ventilation; appropriate respirators are needed in areas where the exposure limit is exceeded; wear self-contained breathing apparatus in oxygen-deficient atmospheres.

**SPILL CLEAN-UP:** Use water spray to disperse vapors and the flush spills away from exposures; collect liquid in an appropriate container or absorb with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; ventilate area of spill after clean-up is complete; remove all sources of ignition.

**HEALTH SYMPTOMS:** Inhalation (irritates nose and throat, headache, severe breathing difficulties, cough, hoarseness, ringing in ears, anesthesia, nausea, vomiting); skin (loss of natural oils, dermatitis); eyes (severe irritation, possible corneal burns, eye damage); ingestion (nausea, vomiting, salivation, burning sensation in mouth and stomach, severe hemorrhagic pneumonitis).

**GENERAL COMMENTS:** Oral rat LD<sub>50</sub> 5 g/kg; First aid: wash eyes with water; wash skin with water and soap; remove to fresh air; wash out mouth with water or milk.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 13; 14; 16.

## **PRIORITY WATER POLLUTANTS (PWPS)**

**ACENAPHTHENE (C<sub>12</sub>H<sub>10</sub>, 154.21)**

**CAS/DOT IDENTIFICATION #:** 83-32-9/UN not available

**SYNONYMS:** 1,8-hydroacenaphthylene; ethylenenaphthalene; periethylenenaphthalene; 1,2-dehydroacenaphthalene, naphthyleneethylene

**PHYSICAL PROPERTIES:** white, crystalline solid; soluble in water and organic solvents; MP (90-95°C); BP (279°C); DN (1.0242 @ 90°C); VP (10 mmHg @ 131.2°C); VD (5.32); solubility in water (3.42 mg/L @ 25°C); OT (8x10<sup>-2</sup> ppm); HV (13078.5 gcal/gmol); Log Kow (4.33); H (0.241x10<sup>-3</sup> atm·m<sup>3</sup>/mole); refractive index (1.6048 @ 95°C).

**CHEMICAL PROPERTIES:** incompatible with ozone and chlorination agents; reacts with oxygen in the presence of alkali-earth metal bromides to form acenaphthequinone; forms crystalline complexes with desoxycholic acid; FP (125°C).

**BIOLOGICAL PROPERTIES:** Koc: 2065 to 3230; will be slightly mobile in soil; degraded by microbes and is readily metabolized by multicellular organisms; aerobic half-life: 12.3-102 days; anaerobic half-life: 49.2-408 days; surface water half-life: 12.5 days; ground water half-life: 24.6-204 days; can be detected in water by EPA Method 610: gas chromatography or high performance liquid chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** bluegill fish half-life: <1 day; BCF (bluegill): 387 after 28-day exposure

**ORIGIN/INDUSTRY SOURCES/USES:** from petroleum refining, shale oil processing, coal tar distilling, combustion of tobacco; used to manufacture dyes, plastics; insecticides and fungicide manufacturing; constituent in asphalt

**TOXICITY:** LC<sub>50</sub> (bluegill: *Lepomis macrochirus*): 1700 µg/L/96-hr in a static bioassay; LC<sub>50</sub> (mysid shrimp: *Mysidopsis bahia*): 970 µg/L/96-hr in a static bioassay; LC<sub>50</sub> (sheepshead minnow: *Cyprinodon variegatus*): 2230 µg/L/96-hr in a static bioassay

**EXPOSURE ROUTES:** cigarette smoke; gasoline exhaust emissions; ingestion of water or foods; inhalation; dermal contact in workplace; recreational contaminated waterways

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 1700 µg/L, 110 µg/L/24-hr avg., concentration not to exceed 240 µg/L any time; **Criterion to protect salt-water aquatic life:** 970 µg/L based on acute toxicity, 520 µg/L based on chronic toxicity, 7.5 µg/L/24-hr avg., concentration not to exceed 17 µg/L any time; **Criterion to protect human health:** 20 µg/L based on organoleptic data

**PROBABLE FATE:** **photolysis:** expected to be an important fate because of the relatively high solubility and strong adsorption above 300 nm, atmospheric and aqueous photolytic half-life: 2.5 days, reaction with photochemically produced hydroxyl radicals half-life: 7.2 hr, should undergo direct photolysis in sunlight; **oxidation:** rapid oxidation occurs with high concentrations of chlorine and ozone, photooxidation half-life in air: 0.879-8.79 hrs; **hydrolysis:** not an important process; **volatilization:** cannot compete with adsorption as a transport process, volatilization half-lives from a model river and a model pond, the latter considers the effect of adsorption, are 11 hr and 39 days, respectively; **sorption:** adsorption onto suspended solids is expected to be the predominate transport process, especially organic matter, adsorption on semi-clay particles from sioccursmulated seawater @ 25°C: 100 µg acenaphthene/L, 50 mg smec-

tite/L, adsorption: nil; **biological processes:** bioaccumulation is short-term, metabolization and biodegradation are principal fate processes

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Gravity oil separation*, not available, 910; *Filtration*, 73, 0.6; *Aerated lagoons*, 0, negative removal; *Activated sludge*, 76->99, <1.5; *Granular activated carbon adsorption*, >93, <0.04; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 30; *Reverse osmosis*, 76-99, 1.5; *continuous activated sludge biological treatment simulator*: 52% removal

**KEY REFERENCES:** 11; 21; 23; 24; 25; 26; 28; 30

### ACENAPHYLENE ( $\text{C}_{12}\text{H}_8$ , 152.20)

**CAS/DOT IDENTIFICATION #:** 208-96-8/UN not available

**SYNONYMS:** 1,2-dehydroacenaphthalene, cyclopenta (de) naphthalene (French)

**PHYSICAL PROPERTIES:** soluble in alcohol, ether, benzene; soluble in water; MP (80-83°C); BP (280°C); DN (0.8988 @ 16°C); SG (0.899); VP ( $9.12 \times 10^{-4}$  mmHg @ 25); solubility (3.93 mg/L @ 25°C in distilled water); water solubility (16 mg/L @ 25°C); Log Kow (4.07), H ( $0.114 \times 10^{-3}$  atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** incompatible with ozone and chlorinating compounds

**BIOLOGICAL PROPERTIES:** Koc: 950-3315; low to slight mobility in soil; at 25-150  $\mu\text{g/L}$ , almost totally degraded within 3 days at ambient temperature, degradation by microbes in ground water contaminated with coal tar products; Eastern Ontario drinking waters: 0.1-2.0 ng/L; Eastern Ontario raw waters: 0.1-0.5 ng/L; biodegradation half-lives in aerobic soil: 12-121 days; aerobic half-life: 42.5-60 days; anaerobic half-life: 170-240 days; surface water half-life: 42.5-60 days; ground water half-life: 85-120 days; can be detected in water by EPA Method 610: extraction followed by high performance liquid chromatography

**BIOACCUMULATION:** Log BCF (regression equations): 2.11-2.76; potential to bio-concentrate in aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES:** in soots generated by the combustion of aromatic hydrocarbon fuels with pyridine; natural fires; component of crude oil, coal tar and a product of combustion; contained in a variety of coal tar products

**TOXICITY:** no data available

**EXPOSURE ROUTES:** produced and released to the environment during natural fires; emissions from petroleum refining and coal tar distillation; manufacturing effluents and the disposal of manufacturing waste by-products; municipal waste water treatment facilities and municipal waste incinerators; dermal contact or inhalation

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** no data available; **Criterion to protect saltwater aquatic life:** no data available; **Criterion to protect human health:** guideline for drinking water: 0.03  $\mu\text{g/L}$  (Kansas)

**PROBABLE FATE:** **photolysis:** rapid photolysis of the dissolved form could be important fate, may undergo direct photolysis in sunlight, reacts with photochemically produced hy-

droxyl radicals and ozone with half-lives of: 5 and 1 hr respectively; **oxidation**: oxidation may occur with high concentrations of chlorine and ozone, photooxidation half-life in air: 0.191-1.27 hrs; **hydrolysis**: not an important process; **volatilization**: probably too slow to compete with adsorption as a transport process, volatilization half-lives from a model river and a model pond, the latter considers the effect of adsorption, are 4 and 184 days, respectively; **sorption**: expected to be adsorbed onto suspended solids, especially organic particulates; **biological processes**: bioaccumulation is short-term, metabolization and biodegradation are the most important fates

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 40; *Sedimentation*, >17, <10; *sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Aerated lagoons*, 0, negative removal; *Activated sludge*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption*, ~100, 2.8

**KEY REFERENCES**: 11; 21; 23; 25; 26; 30

## ACROLEIN ( $\text{C}_3\text{H}_4\text{O}$ , 56.06)

**CAS/DOT IDENTIFICATION #**: 107-02-8/UN 1092

**SYNONYMS**: acraldehyde, acrylic aldehyde, allylaldehyde, 2-propenal, acrylaldehyde, aqaulin, acquinite, acrolein, biocide, crolean, magnacide, slimicide, transacrolein

**PHYSICAL PROPERTIES**: colorless liquid; sharp disagreeable odor; soluble in water, ether, ethanol; miscible in benzene, acetone; MP ( $-87^\circ\text{C}$ ); BP ( $53^\circ\text{C}$ ); DN (0.8389  $\text{g/mL}$  @  $20^\circ\text{C}$ ); SG (0.839); OT (0.2 ppm); VS (0.393 mPa @  $20^\circ\text{C}$ ); VD (1.94); VP (214 mmHg @  $20^\circ\text{C}$ ); ST (24 dynes/cm @  $20^\circ\text{C}$ ); HV (120 cal/g); Log Kow ( $-0.090$ ); H ( $4.4 \times 10^{-6}$  atm $^{-1}$ /mole)

**CHEMICAL PROPERTIES**: incompatible with amines,  $\text{SO}_2$ , metal salts, thiourea, dimethylamine, bases, oxidizers, reducing agents, oxygen; unstable; HC ( $-6950$  cal/g); AT ( $219^\circ\text{C}$ ); FP ( $-6^\circ\text{C}$ ); LFL/UFL (2.8%, 31%)

**BIOLOGICAL PROPERTIES**: BOD is moderate; persistence for several weeks; biodegradation is slow at low concentrations, but will inhibit bacteria at high concentrations; 100% loss when 5 and 10 mg/L underwent a static incubation in the dark @  $25^\circ\text{C}$  with 7 day sewage inoculum; if released to soil, will leach extensively; aerobic half-life: 7 days-4 weeks; anaerobic half-life: 4 weeks-4 months; ground water half-life: 14 days-8 weeks; surface water half-life: 7 days-4 weeks; overall half-life in water: 2-6 days; can be detected in water by EPA Method 603: gas chromatography, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION**: BCF (bluegill sunfish): 344, may have included acrolein metabolites; BCF (estimated based on Log Kow): 0.6; bioconcentration in aquatic organisms is not significant

**ORIGIN/INDUSTRY SOURCES/USES**: pesticides; plastics; perfumes; colloidal forms of metals; organic synthesis; glycerin; acrylic acid; esters; warning agent in methyl chloride refrigerant; military poison mixtures; aquatic herbicide; liquid fuel; algae and aquatic weed control; slimicide in paper manufacture

**TOXICITY**: protozoa (*Uronema parduczi* Chatton-Lwoff): inhibition of cell multiplication starts at 0.44 mg/L; bacteria (*Pseudomonas putida*): inhibition of cell multiplication starts at

0.21 mg/L; algae (*Microcystic aeruginosa*): inhibition of cell multiplication starts at 0.04 mg/L; Fish: goldfish: LD50 (24 hr): <0.08 mg/L; *Lepomis macrochirus*: LC50 (24 hr): 80 µg/L; *Salmo trutta*: LC50 (24 hr): 46 µg/L; fathead minnow: flow through bioassay: incipient TLm: 84 µg/L, maximum acceptable toxicant concentration: 11.4 µg/L

**EXPOSURE ROUTES:** inhalation; ingestion; absorption through skin; intradermal absorption

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 68 µg/L based on acute toxicity, 21 µg/L based on chronic toxicity, 1.2 µg/L/24-hr avg., concentration not to exceed 2.7 µg/L any time; **Criterion to protect saltwater aquatic life:** 55 µg/L based on acute toxicity, 0.88 µg/L/24-hr avg., concentration not to exceed 2.0 µg/L any time; **Criterion to protect human health:** 320 µg/L 6.5 µg/L was also suggested; the following are guidelines in drinking water set by some states: 320 µg/L (Kansas and Arizona)

**PROBABLE FATE:** **photolysis:** photooxidation in atmosphere, photooxidation half-life in air: 3.4-33.7 hrs, reacts with photochemically produced hydroxyl radicals with a half-life of 0.001 hr; **oxidation:** occurs slowly; **hydrolysis:** not an important process; **volatilization:** principle transport mechanism, expected to volatilize quickly from dry soil, volatilization half-life from a model river: 10 days; **sorption:** not an important process; **biological processes:** biotransformation occurs, biodegradation is slow at low concentrations; **reversible hydration:** to beta-hydroxypropionaldehyde, half-life: 21 days

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, >86, <100; *Powdered activated carbon adsorption*, 30, 700000, *Powdered activated carbon adsorption* (based on synthetic wastewater), 93, 2700; *Wet deposition* may remove small amounts from the atmosphere

**KEY REFERENCES:** 11; 19; 21; 22; 23; 24; 25; 26

### ACRYLONITRILE (C<sub>3</sub>H<sub>3</sub>N, 53.06)

**CAS/DOT IDENTIFICATION #:** 107-13-1/UN 1093

**SYNONYMS:** acritet, acrylon, carbacryl, cyanoethylene, fumigrain, propenitrile, VCN, ventox, vinyl cyanide

**PHYSICAL PROPERTIES:** colorless liquid; can have a sweet odor; soluble in isopropyl alcohol, alcohol, ether, acetone, benzene; miscible with ethanol, carbon tetrachloride, ethyl acetate, toluene, petroleum ether, xylene, liquid carbon dioxide; MP (-83°C); BP (77°C); DN (0.8004 g/mL @ 25°C); SG (0.8004); VP (100 mmHg @ 23°C); VD (1.83); VS (0.34 cP @ 25°C); HV (147 cal/g); ST (27.3 dynes/cm @ 24°C); OT (40.4 mg/m<sup>3</sup>); solubility in water (73,500 mg/L @ 20°C); Log Kow (-0.14); H (8.8x10<sup>-5</sup> atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** incompatible with oxidizers, acids, bases, copper, copper alloys, and heat; may polymerize due to exposure to light; HC (-7930 cal/g); AT (480°C); FP (32°F); LFL/UFL (3%, 17%)

**BIOLOGICAL PROPERTIES:** Koc: 9; COD: 1.39; ThOD: 3.17; BOD test is not influenced up to 1 g/l @ 100 mg/L; no inhibition of NH<sub>3</sub> oxidation by *Nitrosomonas*, adsorption to soil is insignificant; aerobic half-life: 1.25-23 days; anaerobic half-life: 5-92 days; soil and sur-

face water half-life: 1.25-23 days; ground water half-life: 2.5-46 days; can be detected in water by EPA Method 603: gas chromatography, or by EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (bluegill): 48 after 28 day exposure or equilibrium; BCF (estimated from water solubility): 1; bioconcentration in aquatic organisms is not significant

**ORIGIN/INDUSTRY SOURCES/USES:** production of acrylic and modacrylic fibers; plastics; rubber elastomers; solvents; polymeric minerals; dyes; pharmaceuticals; insecticides; nylon; fumigant; formation of high-impact resins

**TOXICITY:** Bacteria (*Pseudomonas putida*): inhibition of cell multiplication starts at 53 mg/L; Fish: fathead minnows: 96hr TLM: 14.3 mg/L in hard water, 18.1 mg/L in soft water; bluegill: 96hr TLM: 11.8 mg/L in soft water; guppies: 96hr TLM: 33.5 mg/L in soft water; pin-perch: 96hr and 24hr TLM: 24.5 mg/L in soft water and sea water respectively; bluegill sunfish: 24 hr TLM: 25 mg/L in soft water; minnows: 24 hr TLM: 37.4 mg/L, 48 hr TLM: 24 mg/L

**EXPOSURE ROUTES:** easily adsorbed through skin; inhalation of cigarette smoke and automobile exhaust; fugitive emissions and wastewater during its production and use; release from fibers and plastics

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 7550 µg/L based on acute toxicity, 2600 µg/L based on chronic toxicity over 30 days; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; concentration calculated to keep the lifetime cancer risk level below  $10^{-5}$ : 0.58 µg/L; USSR MAC: 2.0 mg/L for water bodies used for domestic purposes; the following are guidelines in drinking water set by some states: 0.67 µg/L (Minnesota), 3.8 µg/L (Kansas), 10 µg/L (Arizona), 35 µg/L (Connecticut)

**PROBABLE FATE:** **photolysis:** no direct photolysis, indirect photolysis with photosensitizer is probable in atmosphere, reaction with photochemically produced hydroxyl radicals half-life: 3.5 sunlit days; **oxidation:** free radical oxidation is too slow to be important, photooxidation by ultraviolet light in aqueous medium @ 50°C: 24.2% degradation to CO<sub>2</sub> after 24 hr, photooxidation half-life in air: 0.56-8.25 days; **hydrolysis:** not an important process, first-order hydroxyl half-life: 1210 yrs; **volatilization:** high vapor pressure indicates volatilization is the major transport process, will volatilize rapidly from soil and other surfaces, evaporation half-life if released to water: 1-6 days; **sorption:** possible adsorption onto clay particulates; **biological processes:** biodegradation is a very important fate process, biodegradation by mutant microorganisms: 500 mg/L @ 20°C, % distribution: 84% in 24 hr, mutant: 100% in 4.0 hr, acclimation of bacteria increases rate of degradation, biodegradation occurs readily at concentrations <20 mg/L during anaerobic digestion processes at sewage treatment facilities

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 30; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption* (based on synthetic wastewater), 94, 3000, *Continuous activated sludge treatment simulator*: 75-99.9% removal

**KEY REFERENCES:** 11; 19; 21; 22; 23; 25; 26

**ALDRIN (C<sub>12</sub>H<sub>8</sub>Cl<sub>6</sub>, 364.93)**

**CAS/DOT IDENTIFICATION #:** 309-00-2/UN 2761

**SYNONYMS:** 1,2,3,4,10-10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo,exo-5,8-dimethanonaphthalene, HHDN, aldrex, aldrite, aldrosol, drinox, octalene, seedrin liquid

**PHYSICAL PROPERTIES:** brown and white crystalline solid; MP (104-105°C); BP (145°C); DN (1.7 @ 20°C); VP ( $2.3 \times 10^{-5}$  mmHg @ 20°C); solubility in water (0.01 mg/L); OT (0.017 mg/kg water); Log Kow (6.5); H ( $0.496 \times 10^{-3}$  atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** incompatible with concentrated mineral acids, acid catalysts, acid oxidizing agents, phenols, or active metals; corrosive to metals; FP (65°C)

**BIOLOGICAL PROPERTIES:** conversion to dieldrin: 80% after 8 weeks in river water kept in a sealed jar under sunlight and fluorescent light, initial concentration was 10 µg/L; 75-100% disappearance from soils in 1-6 yrs; half-life in water @ 25°C and 1 m depth: 185 hr; aerobic half-life: 3 weeks-1.6 yrs; anaerobic half-life: 1-7 days; ground water half-life: 1 day-3.2 yrs; surface water half-life: 3 weeks-1.6 yrs; soil half-life: 20-100 days; moderately persistent in soil; bind tightly to soil and slowly evaporate to the air; can be detected in water by EPA Method 608: gas chromatography, or Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (5 aquatic mollusks): 350-4500; BCF (golden orfe): 3890; BCF (fish): 10715; BCF (algae: *Chlorella fusca*): 12260; bioconcentration is significant

**ORIGIN/INDUSTRY SOURCES/USES:** insecticide, fumigant; no longer produced or used in the USA

**TOXICITY:** 96 hr static lab bioassays: Korean shrimp (*Palaemon macrodactylus*): 0.74 ppb, Sand shrimp (*Crangon septemspinosa*): 8 ppb, Grass shrimp (*Palaemonetes vulgaris*): 9 ppb, Hermit crab (*Pagurus longicarpus*): 33 ppb, Striped killifish (*Fundulus majalis*): 17 ppb, Atlantic silverside (*Menidia menidia*): 13 ppb, Striped mullet (*Mugil cephalus*): 100 ppb, Blue-head (*Thalassoma bifasciatum*): 12 ppb; *Daphnia magna*: LC<sub>50</sub>, 24 hr: 30 µg/L, 48 hr: 29 µg/L; Striped bass (*Morone saxatilis*): 96-hr LC<sub>50</sub>: 0.010 mg/L; bluegill, 24 hr LC<sub>50</sub>: 260 ppb, 96 hr LC<sub>50</sub>: 0.013 ppm; rainbow trout, 96 hr LC<sub>50</sub>: 0.036 ppm; much more data available from other sources

**EXPOSURE ROUTES:** air; water; food; inhalation; skin adsorption; ingestion; eye and skin contact; pesticide manufacturers, formulators, and applicators

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life: 3.0 µg/L, 0.0019 µg/L/24 hr avg., concentration not to exceed 1.2 µg/L any time; Criterion to protect saltwater aquatic life: 1.3 µg/L, 0.0069 µg/L/24-hr avg., concentration not to exceed 0.16 µg/L any time; Criterion to protect human health: preferably 0; concentration calculated to keep the lifetime cancer risk level below 10<sup>-5</sup>: 0.00074 µg/L; USSR MAC: 0.01 mg/L; the following are guidelines in drinking water set by some states: 0.1 µg/L (Illinois), 0.013 µg/L (Kansas), 0.03 µg/L (Minnesota), 0.05 µg/L (California)

**PROBABLE FATE:** *photolysis*: direct photolysis is slow, indirect photolysis may be important, vapor phase aldrin residues expected to react with photochemically produced hydroxyl radicals with a half-life of 35.46 min; *oxidation*: reacts to form dieldrin, photooxidation by ultraviolet light in aqueous medium @ 90-95°C forms 25% CO<sub>2</sub> in 14.1 hr, 50% CO<sub>2</sub> in 28.2 hr, 75% CO<sub>2</sub> in 109.7 hr, photooxidation half-life in air: 0.9-9.1 hrs; *hydrolysis*: too slow to be an important process; *volatilization*: an important process, evaporation rate from water:  $3.72 \times 10^{-3}$  m/hr, will volatilize from soil surfaces; *sorption*: an important process, adsorption to sediment is

significant; **biological processes:** biotransformation to dieldrin is expected to be the dominant transformation process in aquatic organisms; biodegradation is expected to be slow

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 3; *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated sludge adsorption* (based on synthetic wastewater), 95, 1.2

**KEY REFERENCES:** 21; 22; 23; 24; 25; 26; 28; 30; 31

### **ANTHRACENE (C<sub>14</sub>H<sub>10</sub>, 178.2)**

**CAS/DOT IDENTIFICATION #:** 120-12-7/UN not available

**SYNONYMS:** Paranaphthalene, green oil, anthracene

**PHYSICAL PROPERTIES:** white to yellow crystalline solid; weak, aromatic odor; MP (216.5°C); BP (342°C); DN (1.28 g/mL); SG (1.25); VP ( $1.95 \times 10^{-4}$  torr @ 20°C); VD (6.15); solubility in water (0.073 mg/L @ 25°C); Log Kow (4.45)

**CHEMICAL PROPERTIES:** incompatible with oxidizing materials; combustible solid; reacts explosively with flame,  $\text{Ca}(\text{OCl})_2$  and chromic acid; FP (121°C); LEL (0.6%); AT (538°C)

**BIOLOGICAL PROPERTIES:** BOD<sub>5</sub>: 2% of ThOD and 0% of ThOD; Cod: 35% and 94% of ThOD; biodegrades to CO<sub>2</sub>; leaching into groundwater is not expected; will strongly adsorb to sediment and particulate matter if released to soil or water; aerobic half-life: 50 days-1.26 yrs; anaerobic half-life: 200 days-5.04 yrs; surface water half-life: 0.58-1.7 hrs; ground water half-life: 100 days-2.52 yrs

**BIOACCUMULATION:** BCF (*Daphnia pulex*): 760, initial concentration in water: 0.02 ppb, equilibrium reached after 4 hr; may bioconcentrate in species which lack microsomal oxidase; concentration found in fish tissues is expected to be much higher than the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** dyestuffs; insecticides; wood preservatives; coke oven emissions; coal tar pitch; gasoline; gasoline engine

**TOXICITY:** high acute and chronic toxicity to aquatic life; fish (trout): no effect level: 5 mg/L, 24 hr

**EXPOSURE ROUTES:** high exposure from smoking cigarettes and the ingestion of certain foods (e.g. smoked and charcoal broiled meats and fish); industrial and municipal discharges; inhalation of contaminated air; consumption of contaminated food and water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** concentrations calculated to keep the lifetime cancer risk level below  $10^{-5}$ ,  $10^{-6}$ , and  $10^{-7}$  are: 0.097-9.7 ng/L respectively proposed by EPA; Kansas has set a guideline in drinking water of 0.029  $\mu\text{g/L}$

**PROBABLE FATE:** *photolysis:* rapid photolysis occurs only for dissolved portion, therefore, increased adsorption significantly decreases photolysis, atmospheric and aqueous

photolytic half-life: 0.58-1.7 hrs; direct photolysis near the surface of waters, reaction with photochemically produced hydroxyl radicals has a half-life of 1.67 days; **oxidation**: ozone and chlorine in sufficient quantities can oxidize dissolved anthracene, photooxidation half-life in water: 46.3 days-4.39 yrs, photooxidation half-life in air: 0.501-5.01 hrs; **hydrolysis**: not an important process; **volatilization**: volatilization is hindered by adsorption and is significant only in shallow, clear, well mixed streams, evaporation half-life from a river 1 m deep, flowing at 1 m/sec with a wind velocity of 3 m/sec: 4.3-5.9 days; **sorption**: adsorption on smectite clay particles from simulated seawater @ 25°C, 100 µg anthracene/L, 50 mg smectite/L-adsorption: 0.90 µg/mg=46% adsorbed; **biological processes**: short-term bioaccumulation, metabolization and biodegradation are the ultimate fates, biodegradation in soils have half-lives of 3.3-139 days

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 3; *Gas flotation*, 45, ~600; *Gas flotation with chemical addition (calcium chloride, polymer)*, 83, 66; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Filtration*, 40-70, 400; *Sedimentation*, 55-92, <14; *Sedimentation with chemical addition (lime, polymer, or alum)*, 0, negative removal; *Ozonation*, 48->97, 0.2; *Activated sludge*, 57->97, <2.5; *Granular activated carbon adsorption*, >63->97, <2.5; *Reverse osmosis*, 77, 0.7; *Continuous activated sludge biological treatment simulator*: 97% removal

**KEY REFERENCES**: 21; 23; 24; 25; 26; 27; 28; 30

### **ANTIMONY (Sb, 121.75)**

**CAS/DOT IDENTIFICATION #**: 7440-36-0/UN 2871

**SYNONYMS**: antimony black, antimony, regulus, stibium

**PHYSICAL PROPERTIES**: silver-white, lustrous; insoluble in hot and cold water; MP (630°C); BP (1635°C); DN (6.684 @ 25°C); VP (1 mmHg @ 886°C); VD (4.2); HV (195100 J/mol);

**CHEMICAL PROPERTIES**: slightly oxidized in air; incompatible with oxidizers, acids, and halogenated acids; reacts with sulfur and chlorine to form the tri- and pentavalent sulfides and chlorides; trivalent state shows cationic behavior

**BIOLOGICAL PROPERTIES**: will persist until natural alkalinity precipitates as oxide; attaches to small particulates in air and remains for many days; most ends up in soil and attaches to particulates containing iron, manganese, or aluminum; found in low levels in rivers, lakes, and streams; 35 ppt of salinity @ 0.3 µg/L in seawater and at 1.1 µg/L in freshwater streams; highly persistent in water with a half-life of longer than 200 days; can be detected in water by atomic absorption; 0.2 µg/L found in tap water; found in some foods in the parts per million range

**BIOACCUMULATION**: accumulation in lungs in exposed workers; concentration found in fish tissues is expected to be about the same as the average concentration found in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES**: manufacture of white metal, bullets, bearing metal; in fireworks; thermoelectric piles; coating metal; blackening iron; semiconductor devices; paint pigments; rubber vulcanization agents; ceramic additive; alloys; antimony oxide; lead storage batteries; solder

**TOXICITY:** high acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** primarily in food, drinking water, and air; air near industries such as smelters, coal fired-plants, and refuse incinerators; inhalation of dust or fume; skin and eye contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 9000 µg/L based on acute toxicity, 1600 µg/L based on chronic toxicity, 120 µg/L/24 hr avg., concentration not to exceed 1000 µg/L any time; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** 146 µg/L; ambient limit: 7 µg/L based on health effects proposed by EPA; USSR MAC: 0.05 mg/L in water used for domestic purposes; Kansas has set a guideline in drinking water of: 143 µg/L

**PROBABLE FATE:** **photolysis:** not important under natural conditions; **oxidation:** present as soluble oxide or antimonite salts under natural redox conditions; **hydrolysis:** oxide or antimonite acid formed by hydrolysis; **volatilization:** not important under natural redox conditions; **sorption:** adsorbed to clays, coprecipitates with iron and aluminum compounds; **biological processes:** slight bioaccumulation and probable biomethylation;

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 290; *Gas flotation with chemical addition (calcium chloride, polymer)*, 47-89, <78; *Gas flotation with chemical addition (alum, polymer)*, 6, 2200; *Filtration*, 26-89, 320; *Sedimentation*, 44-98, 310; *Sedimentation with chemical addition (Fe<sup>2+</sup>, lime)*, 8-30, 13; *Sedimentation with chemical addition (polymer)*, 44, 43; *Sedimentation with chemical addition (BaCl<sub>2</sub>)*, 70, <50; *Sedimentation with chemical addition (lime)*, 38-93, 30; *Aerated lagoons*, 82, 30; *Activated sludge*, 30-90, 46; *Powdered activated carbon adsorption (with activated sludge)*, 5, 41; *Granular activated carbon adsorption*, 12-33, 160; *Reverse osmosis*, 26-60, 77

**KEY REFERENCES:** 11; 20; 21; 23; 24; 27; 31

## ARSENIC (As, 74.92)

**CAS/DOT IDENTIFICATION #:** 7440-38-2/UN 1558

**SYNONYMS:** arsen, Fowler's solution, grey arsenic, colloidal arsenic

**PHYSICAL PROPERTIES:** gray, crystalline material; soluble inorganic arsenate (arsenic trioxide) predominates under normal conditions; MP (817°C @ 28 atm); BP (613°C); SG (5.727); VP (1 mmHg @ 372°F)

**CHEMICAL PROPERTIES:** forms a complete series of trihalides; can react strongly with strong oxidizers; forms highly toxic fumes on contact with acids or active metals

**BIOLOGICAL PROPERTIES:** surface water samples have concentrations ranging from 5 to 336 µg/L; seawater concentration: 3.0 µg/L; highly persistent in water, with a half-life of more than 200 days; can be detected in water by digestion followed by silver diethyldithiocarbamate, atomic adsorption, or inductively coupled plasma optical emission spectrometry

**BIOACCUMULATION:** bioconcentrates in both fresh and saltwater organisms; does not accumulate in plants to toxic levels; concentration found in fish tissues is expected to be somewhat higher than the average concentration found in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** naturally occurring element; coal fuel power plants; manufacturing of glass, cloth, and electrical semiconductors; fungicides; wood preservatives; growth stimulates for plants and animals; veterinary medicine

**TOXICITY:** high acute toxicity to aquatic life

**EXPOSURE ROUTES:** found in air and all living organisms; people living within 12 miles of copper, zinc, and lead smelters may be exposed to 10 times the USA avg. atmospheric levels; 40,000 people living near some copper smelters may be exposed 100 times the national atmospheric avg.; inhalation and ingestion of dust and fumes

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 57  $\mu\text{g/L}/24$  hr avg., concentration not to exceed 130  $\mu\text{g/L}$  any time, total recoverable trivalent inorganic arsenic never to exceed 440  $\mu\text{g/L}$ ; **Criterion to protect saltwater aquatic life:** 29  $\mu\text{g/L}/24$  hr avg., concentration not to exceed 67  $\mu\text{g/L}$  any time, 508  $\mu\text{g/L}$  based on acute toxicity; **Criterion to protect human health:** maximum allowable level: 50  $\mu\text{g/L}$ , preferably; concentrations calculated to keep the cancer risk level below  $10^{-5}$ ,  $10^{-6}$ , and  $10^{-7}$  are 0.02, 0.002, and 0.0002  $\mu\text{g/L}$  respectively; Maine has set a guideline in drinking water of 0.05 mg/L

**PROBABLE FATE:** **photolysis:** not an important process; **oxidation:** under reducing conditions, it is a stable solid, dissolved arsenic is present in oxygenated water; **hydrolysis:** all arsenic halides hydrolyze in presence of water; hydrolyzed to arsenious and arsenic acid forms (soluble); **volatilization:** not important under natural redox conditions; **sorption:** removed by clays, iron oxides, manganese oxides, and aluminum; **biological processes:** bioaccumulated, but not biomagnified, biotransformed to organic arsenicals

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 46; *Gas flotation with chemical addition (calcium chloride, polymer)*, >28-80, <8.5; *Gas flotation with chemical addition (alum, polymer)*, 56, 3.5; *Filtration*, 31->99, 28; *Sedimentation*, 68->99, 72; *Sedimentation with chemical addition (lime, polymer)*, 37-75, 10; *Sedimentation with chemical addition ( $\text{Fe}^{2+}$ , lime)*, >69-99, <2; *Sedimentation with chemical addition (sulfide)*, >99, 5; *Sedimentation with chemical addition ( $\text{BaCl}_2$ )*, 17->33, <8.5; *Sedimentation with chemical addition (alum, polymer)*, 29, 12; *Sedimentation with chemical addition (lime)*, 60->99, <16; *Ozonation*, 24-48, 23; *Activated sludge*, >43->96, 35; *Granular activated carbon adsorption*, 21->99, 11; *Reverse osmosis*, 79->99, 7.7

**KEY REFERENCES:** 21; 23; 24; 27

**ASBESTOS** (most common form is chrysotile,  $\text{Mg}_3(\text{Si}_4\text{O}_{10})\text{OH}_8$ ), not applicable)

**CAS/DOT IDENTIFICATION #:** 1332-21-4/ UN 2212, 2590

**SYNONYMS:** 4TO4, 7NO5, 7RF10, chrysotile, amosite, crocidolite, asbestos fibers, synthetic fibers, AT 7-1, calidrea-hop, mountain-cork, mountain-leather, mountain wood, P-5-50, white asbestos

**PHYSICAL PROPERTIES:** a group of six different minerals occurring naturally in the environment; most common type is white; others are blue, gray, or brown; long thin fibers similar to fiberglass; not volatile; not soluble; serpentine asbestos: chrysotile mineral, strong, resistant to chemicals and heat; amphibole asbestos: brittle fibers, resistant to chemicals and heat

**CHEMICAL PROPERTIES:** noncombustible; fire-resistant fibers; completely decomposed at 1,000°C; both the dehydroxylation temperature and decomposition temperature increase with increased MgO content; organic acids have a tendency to react slowly with chrysotile

**BIOLOGICAL PROPERTIES:** highly persistent in water; half-life is greater than 200 days; asbestos can be present in surface and ground water; small fibers and fiber-containing particles may be carried long distances by water currents before settling to the bottom; larger fibers and particle settle more quickly; considered to be non-biodegradable by aquatic organisms; chrysotile is almost completely destroyed within one hour in 1N HCl @ 95°C; the resistance of the asbestos fibers to attack by reagents other than acids is excellent up to temperatures of about 100°C with rapid deterioration at higher temperatures; chrysotile is completely decomposed in concentrated KOH at 200°C

**BIOACCUMULATION:** no data regarding the bioaccumulation in aquatic organisms; concentration found in fish tissues is expected to be less than the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** used in building materials, paper products, asbestos cement products; textiles; packings; gaskets; pipes; ducts; valves; flanges; clutch/transmission components; electronic motor components; molten glass handling equipment; hoods; vessel manufacturing; floor tiles; paint filler; fireproof fabrics; brake lining; roofing compositions; laboratory furniture; cooling towers

**TOXICITY:** asbestos fibers can cause cancer when chronically inhaled; insufficient data to determine if asbestos poses any acute toxicity hazard to aquatic life

**EXPOSURE ROUTES:** inhalation; ingestion; erosion of natural deposits in asbestos-bearing rocks; asbestos related industries; mining and processing some minerals; clutches and brakes on cars; outdoor air; insulation; ceiling and floor tiles; corrosion from asbestos-cement pipes; disintegration of asbestos roofing materials; drinking water

**REGULATORY STATUS:** MCLG: 7 million fibers/L (fibers >10 $\mu$  in length); MCL (7 million fibers/L); HAL (child): none; **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; the concentration to keep the lifetime cancer risk level of  $1 \times 10^{-5}$ ,  $10^{-6}$ , and  $10^{-7}$  is 300,000, 30,000, and 3,000 fibers/L respectively; a maximum level in drinking water proposed by EPA is 7 million fibers/L; Kansas and Minnesota have set guidelines in drinking water

**PROBABLE FATE:** *photolysis:* not photolyzed under environmental conditions; *oxidation:* not resistant to oxidation; *hydrolysis:* not hydrolyzed under environmental conditions; *volatilization:* negligible from aqueous solutions, may be aerosol under windy conditions; *sorption:* does not have an adsorptive affinity for solids normally found in natural water systems, some materials (trace metals and organic compounds) have an affinity for asbestos minerals; *biological processes:* no evidence was found regarding bioaccumulation; *other reactions/interactions:* asbestos is refractory in the aquatic environment

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $10^6$  fibers/L)): *Filtration*, 90->99, 470; *Sedimentation*, 80->99, 3,000; *Sedimentation*

with chemical addition (lime, polymer), >99, 8.2; Sedimentation with chemical addition ( $BaCl_2$ ), 38-75, 140; Sedimentation with chemical addition (lime), 95, 6.1

**KEY REFERENCES:** 19; 21; 23; 24; 27; 29

### **BENZENE (C<sub>6</sub>H<sub>6</sub>, 78.12)**

**CAS/DOT IDENTIFICATION #:** 71-43-2/UN 1114, 1115

**SYNONYMS:** annulene, benzeen, benzol, benzole, coal naphtha, cyclohexatriene, phene, phenyl-hydride, polystream, pyrobenzol, pyrobenzole, many others

**PHYSICAL PROPERTIES:** clear, colorless liquid; aromatic odor; negligibly soluble in water; miscible with alcohol, ether, acetone, carbon tetrachloride; MP (5.5°C); BP (80°C); DN (0.8787 g/mL @ 15°C); specific gravity (0.88); VP (1 mm @ -36.7°C); VD (2.77); ST (28.9 dynes/cm); VS (0.6468 mP @ 20°C); OT (1.5 ppm); HV (94.1 cal/g); H ( $5.55 \times 10^{-3}$  atm<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** generally very stable; will not polymerize; will react vigorously with strong oxidizing agents, sulfuric acid, nitric acid, chlorine, oxygen, ozone, permanganates, peroxides, perchlorates; FP (-11°C); LFL/UFL (1.3%, 7.1%); AT (562°C); HC (-9.698 cal/g)

**BIOLOGICAL PROPERTIES:** TOC: 40% ThOD; ThOD: 3.10; 33% theoretical oxidation of 500 ppm benzene by phenol-acclimated sludge after 12 hr aeration; aerobic half-life: 5-16 days; anaerobic half-life: 16 weeks-24 months; can be detected in water by EPA Method 602: gas chromatography, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** low potential for bioaccumulation; concentration found in fish tissues is expected to be somewhat higher than the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of dyes, styrene, phenol, organic compounds, linoleum, varnishes, lacquers, resins, medicines, cumene, cyclohexane, nitrobenzene, chlorobenzenes, sulfonic acid; paint; printing; dry cleaning; coatings; adhesives; rubber; detergents; inks; paint thinners; degreasing agents; tires; shoes

**TOXICITY:** Toxicity threshold (cell multiplication test): bacteria (*Pseudomonas putida*): 92 mg/L, algae (*Microcystis aeruginosa*): >1400 mg/L, green algae (*Scenedesmus quadricauda*): >1400 mg/L, protozoa (*Entosiphon sulcatum*): >700 mg/L; protozoa (*Uronema parduczi Chatton-Lwoff*): 486 mg/L; Fish: minnows: min. lethal dose (6hr): 5-7 mg/L, bluegill sunfish: LD<sub>50</sub>: 24-48 hr: 20 mg/L, guppies: soft water: TLm (24,96 hr): 36.6 mg/L; guppy (*Poecilia reticulata*): 14 d, LC<sub>50</sub>: 63 ppm

**EXPOSURE ROUTES:** primarily by inhalation; adsorption through eyes and skin; ingestion; cigarette smoke; emissions from burning coal and oil; motor vehicle exhaust; evaporation of gasoline at service stations; occupational exposure; drinking of contaminated water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 5,300 µg/L based on acute toxicity, 3,100 µg/L/24 hr avg., concentration not to exceed 7,000 µg/L any time; **Criterion to protect saltwater aquatic life:** 5100 µg/L based on acute toxicity, 920 µg/L/24 hr avg., concentration not to exceed 2,100 µg/L any time; **Criterion to protect human health:**

preferably 0; concentration calculated to keep the lifetime cancer risk level of  $1 \times 10^{-5}$ : 6.6  $\mu\text{g/L}$ ; the following are standards and guidelines in drinking water set by some states: 1.0  $\mu\text{g/L}$  (Florida and New Jersey), 10  $\mu\text{g/L}$  (New Mexico); 10 day health advisory: 0.235  $\text{mg/L}$  for a 10kg child; USSR MAC: 0.5  $\text{mg/L}$  in water bodies used for domestic and for fishery purposes

**PROBABLE FATE:** *photolysis*: photooxidation of volatilized benzene is the only form of photolysis that occurs, atmospheric and aqueous photolytic half-life: 117-673 days, photooxidation half-life in water: 334 days-36.6 yrs, photooxidation half-life in air: 2.09-20.9 days; *oxidation*: no aqueous oxidation occurs, but volatilized benzene is photooxidized at a rapid rate; *hydrolysis*: not an important process; *volatilization*: rapid volatilization is the primary transport process, half-life: 4.81 hr; *sorption*: should be adsorbed by organic material; *biological processes*: low potential for bioaccumulation, metabolized to catechols by many organisms, biodegraded at a slow rate

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, NA, >75; *Gas flotation with chemical addition (calcium chloride, polymer)*, 0, negative removal; *Gas flotation with chemical addition (polymer)*, 33, 12; *Filtration*, 28->99, 45; *Sedimentation*, 23->63, 85; *Sedimentation with chemical addition (alum, lime)*, 50, 46; *Sedimentation with chemical addition (alum, polymer)*, 49->97, 160; *Anaerobic lagoons*, 50, 5000; *Aerated lagoons*, 56->95, <16; *Solvent extraction*, 90-97, 11,000; *Activated sludge*, 49->99, 4100; *Powdered activated carbon adsorption*, 95, 20,000; *Granular activated carbon adsorption*, 48->80, 73; *Reverse osmosis*, 43-80, 1.5; *continuous activated sludge biological treatment simulators*: 44%-100% removal

**KEY REFERENCES:** 11; 19; 21; 23; 24; 25; 26; 27; 28

## BENZIDINE ( $\text{C}_{12}\text{H}_{12}\text{N}_2$ , 184.26)

**CAS/DOT IDENTIFICATION #:** 92-87-5/UN 1885

**SYNONYMS:** p-benzene, 4,4'-bianiline, biphenyl-4,4'-diamine, (1,1'-biphenyl)-4,4'-diamine, 4,4'-biphenyl diamine, 4,4'-diaminobiphenyl, fast corinth base B, many others

**PHYSICAL PROPERTIES:** grayish, yellow, white, or slightly reddish crystal powder; insoluble in water; odorless; MP (117°C); BP (400°C); DN (1.250  $\text{g/cm}^3$  @ 20°C); SG (1.25 @ 68°C); VP ( $5 \times 10^{-4}$  mmHg @ 25°C); VD (6.36); solubility in water (400  $\text{mg/L}$  @ 12°C); Log Kow (1.34); H ( $0.388 \times 10^{-10}$  atm- $\text{m}^3/\text{mole}$ )

**CHEMICAL PROPERTIES:** will darken when exposed to light or air; may be sublimed; forms insoluble salts with sulfuric acid; can be diazotized and oxidized; amino groups can be acetylated and alkylated; incompatible with oxidizing materials

**BIOLOGICAL PROPERTIES:** highly persistent in water; some products are produced by biooxidation; can be oxidized by metal cations; rate of degradation in soil: 79% degradation in 4 weeks and 10% mineralization in 1 yr; aerobic half-life: 2-8 days; anaerobic half-life: 8-32 days; ground water half-life: 4-16 days; surface water half-life: 1.3-8 days; can be detected in water by EPA Method 605: high performance liquid chromatography, or EPA Method 625: gas chromatography plus mass spectrometry; it can also be detected by an oxidation/colorimetric method using Chloramine T (available from EPA)

**BIOACCUMULATION:** Log BCF (bluegills): 1.6 in edible portion of fish from a 42 day experiment; after 3 days in a model ecosystem, Log BCF (fish, mosquitos, snail, and algae):

1.74, 2.66, 2.81, 3.4 respectively; will bioconcentrate moderately in fish; concentration in fish is expected to be about the same as the concentration of the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** found as a free base in natural waters; manufacture of azo dyes; intermediate in synthesis of various colors; plastic films; determination of nicotine (quantitative); hardener in rubber compounds; reagent; spray reagent for sugars; detection of hydrogen cyanide and sulfate; detection of blood stains; lignification measurement

**TOXICITY:** moderate acute and moderate chronic toxicity to aquatic life; scud (*Gammarus pseudolimnaeus*): LC50: 20,000 µg/L/96-hr; fathead minnow (*Pimephales promelas*): LC50: 20,000 µg/L/96-hr; rainbow trout (*Salmo gairdneri*): LC50: 7400 µg/L/96-hr; flagfish (*Jordanella floridae*): 16,200 µg/L/96-hr

**EXPOSURE ROUTES:** primarily occupational exposure; inhalation of fine powders; direct contact with skin or eyes; ingestion; adsorption through skin; drinking contaminated water; inhalation of dust or mist of azo dyes

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 2500 µg/L based on acute toxicity; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; the concentration calculated to keep the lifetime cancer risk level below 10<sup>-5</sup>: 0.0012 µg/L; Kansas has set a drinking water guideline of 0.0015 µg/L

**PROBABLE FATE:** **photolysis:** possible but actual significance is uncertain; will also degrade by reactions with radicals; **oxidation:** oxidation by metal cations is very fast, reactions with oxygen and/or peroxy radicals are very important, photooxidation half-life in water: 1.3-72.5 days, photooxidation half-life in air: 0.312-3.12 hrs; **hydrolysis:** not an important process; **volatilization:** not an important process; **sorption:** very rapid adsorption by clay minerals, if spilled on soil, it will adsorb to it, especially if the soil is acidic; **biological processes:** no bioaccumulation, only slight biodegradation

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Aerated lagoons*, 41, 7; *Activated sludge*, 0, negative removal; *continuous biological treatment simulators utilizing activated sludge (low percentage) and domestic sludge (high percentage) inoculums*: 65%-91% removal; subject to gravitational settling and wash-out

**KEY REFERENCES:** 11; 19; 21; 22; 23; 25; 26; 27; 30

## **BENZO (a) ANTHRACENE (C<sub>18</sub>H<sub>12</sub>, 228.30)**

**CAS/DOT IDENTIFICATION #:** 56-55-3/ UN 2811

**SYNONYMS:** benz (a) anthracene, 1,2-benz (a) anthracene, 1,2-benzanthracene, 1,2-benzanthrene, 2,3-benzophenanthrene, ba, benzanthrene, benzo (b) phenanthrene, naphthanthracene, tetraphene

**PHYSICAL PROPERTIES:** colorless plates; soluble in ether, alcohol, acetone, benzene; soluble in most organic solvents; slightly soluble in acetic acid; MP (162°C); BP (435°C, sublimes); VP (5x10<sup>-9</sup> mmHg @ 20°C); solubility in water (0.014 mg/L @ 25°C); Log Kow (5.61)

**CHEMICAL PROPERTIES:** oxidation to quinones and carboxylic acids; stable

**BIOLOGICAL PROPERTIES:** bacteria and fungi exist in the environment that degrade benzo (a) anthracene; degradation in sediment: 1.4-1.8% per week in a seawater-sediment slurry environment which indicates a half-life of 199-252 days; a half-life of 290 days was found in another study from an oil-contaminated stream, and a half-life 10 to 400 times as long in an uncontaminated stream; microbial degradation is faster in the upper layers of sediment; in some situations, degradation is limited by lack of nutrients in the water; will not leach into ground water; aerobic half-life: 102 days-1.86 yrs; anaerobic half-life: 1.12-7.45 yrs; ground water half-life: 204 days-3.73 yrs; can be detected in wastewater by EPA Methods 625 and 1625: extraction with methylene chloride followed by gas chromatography/ mass spectrometry

**BIOACCUMULATION:** Log BCF(daphnia): 4.0; BCF (oysters): 3.03; Log BCF (calculated): 4.04; strongly adsorbed by bacteria; no data on bioconcentration in fish

**ORIGIN/INDUSTRY SOURCES/USES:** research chemical; no evidence of commercial use; found in oil, wax, smoke, food, and drugs

**TOXICITY:** data on aquatic organisms is unavailable

**EXPOSURE ROUTES:** inhalation; ingestion; cigarette smoke condensate; automobile exhaust; soot; emissions from coal and gas works and electric plants; aromatic fraction of mineral oil; commercial solvents, waxes, petrolatum, creosote, coal tar, petroleum asphalt, coal tar pitch; charcoal broiled barbecued, or smoke meats and fish; certain vegetables and vegetable oils; coffee

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** concentration calculated to keep the life-time cancer-risk to 1 in a million: 2.8 ng PAH/L; Kansas has set a guideline in drinking water of 0.029 µg/L

**PROBABLE FATE:** **photolysis:** photolysis to quinones is rapid, but is greatly hindered by adsorption, atmospheric and aqueous photolytic half-life: 1-3 hrs, in the unadsorbed state, will degrade by photolysis from hours to days; **oxidation:** oxidation by alkyl peroxy radicals could compete with photolysis dissolved benzo (a) anthracene, photooxidation half-life in water: 3.2-160 days; photooxidation oxidation half-life in air: 0.801-8.01 hrs; **hydrolysis:** not an important process; **volatilization:** too slow to compete with sorption as a transport process; **sorption:** very strong adsorption by suspended solids is the principal transport process, when released to water, will quickly adsorb to sediment or particulate matter; **biological processes:** short-term bioaccumulation is accompanied by metabolization, biodegradation is the principal fate, but occurs slowly

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 55; *Sedimentation with chemical addition (lime, polymer)*, >81, <10; *Sedimentation with chemical addition (lime)*, >92, <10; *Activated sludge*, 41, 2950; *Granular activated carbon adsorption*, >93->97, <0.02

**KEY REFERENCES:** 11; 21; 23; 24; 26; 28; 30

**BENZO (a) PYRENE (C<sub>20</sub>H<sub>12</sub>, 252.3)**

**CAS/DOT IDENTIFICATION #:** 50-32-8/ UN 9188

**SYNONYMS:** 3,4-benzopyrene; B[a]P, 1,2-benzopyrene, 3,3-benzopyrene, benzo (d,e,f)chrysene, 6,7-benzopyrene, benz (a) pyrene, 3,4-BP

**PHYSICAL PROPERTIES:** yellowish crystals; faint aromatic odor; MP (179); BP (310-312 @ 10 torr); DN (1.351 g/mL); VP ( $5 \times 10^{-9}$  torr); VD (8.7); solubility in water (0.0038 mg/L @ 25°C); Log Kow (6.04)

**CHEMICAL PROPERTIES:** nonflammable; incompatible with nitrogen dioxide and ozone; readily undergoes nitration and halogenation; hydrogenation occurs with platinum oxide

**BIOLOGICAL PROPERTIES:** microbial degradation to CO<sub>2</sub> in seawater at 12°C in the dark, 48 hr incubation @ 16 µg/L:0 µg/L/day, after addition of water extract of #2 fuel oil, 24 hr incubation: 0.01 µg/L/day, turnover time: 1400 days; can be transported long distances; will not leach to groundwater; can be detected in water by EPA Methods 610 and 625: gas chromatography or high performance liquid chromatography, or gas chromatography plus mass spectrometry

**BIOACCUMULATION:** when released to water, will bioconcentrate in aquatic organisms which cannot metabolize; Oysters (*Crassostrea virginica*) from oil treated enclosure: 2 days exposure, oysters concentration: 0.36 µg/g, water concentration: 1.9 µg/L, accumulation factor (oysters/water): 190; 8 days exposure: oysters concentration: 0.30 µg/g, water concentration: 0.1 µg/L, accumulation factor (oysters/water): 3,000

**ORIGIN/INDUSTRY SOURCES/USES:** produced from coal tar processing, petroleum refining, heat and power generation sources; no commercial-scale production; produced and distributed for research purposes, extensively in cancer research; by-product of chemical production, combustion of tobacco and fuels

**TOXICITY:** *Neanthes arenaceodentata*: 96 hr TLm in seawater @ 22°C:>1 ppm (initial concentration in static assay); atlantic salmon (*Salmo salar*): eggs: 168 hr BCF 70.7 (static test)

**EXPOSURE ROUTES:** workers at airports in tarring operations; refuse incinerator operations; power plants; coke manufacturing; scientists involved in cancer research; air pollution; cigarette smoke; certain foods; gasoline; motor-oil; asphalt; crude and diesel oils

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** **Criterion to protect saltwater aquatic life:** **Criterion to protect human health:** concentration calculated to keep the life-time cancer-risk to 1 in a million: 2.8 ng PAH/L; USSR MAC: 0.005 µg/L in water used for domestic purposes; Kansas has set a guideline in drinking water of 0.03 µg/L, and New Mexico a standard of 10 µg/L

**PROBABLE FATE:** **photolysis:** dissolved portion should undergo rapid photolysis to quinones, when released to air, may undergo direct photolysis, although adsorption can slow this process, direct photolysis is important near surface of waters; half-life for reaction with photochemically produced hydroxyl radicals: 21.49 hr; **oxidation:** oxidation by chlorine and/or ozone could account for a small portion of the dissolved compound; **hydrolysis:** not an important process; **volatilization:** probably too slow to compete with adsorption as a transport process, evaporation may be important, but limited by adsorption, half-life: 43 days; **sorption:** very strong adsorption onto suspended solids is the dominant transport process, adsorption in estuarine water: @ 3 µg/L, 71% adsorbed on particles after 3 hr, after 3hr incubation in natural seawater, 75% of 2 µg/L adsorbed to suspended aggregates of dead photoplankton cells and bacteria; **biological processes:** bioaccumulation is short-term; metabolization and microbial degradation are principal fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 15.5; *Filtration*, 0, negative removal; *Sedimentation*, >70-98, <5.3; *Sedimentation with chemical addition (lime, polymer)*; 0, negative removal; *Sedimentation with chemical addition (lime)*; 0, negative removal; *Aerated lagoons*, 33, 2; *Powdered activated carbon adsorption* (based on synthetic wastewater) 98, 0.03; *Ozonation*; >90, <0.02; *chlorination*, 6 mg/L chlorine for 6 hr, initial concentration: 53.14 ppb: 98% reduction; may be removed by reaction with  $\text{O}_3$  (half-life 37 min), and  $\text{NO}_2$  (half-life 7 days)

**KEY REFERENCES:** 21; 23; 25; 28; 30

### **BENZO (g,h,i) PERYLENE ( $\text{C}_{22}\text{H}_{12}$ , 276.34)**

**CAS/DOT IDENTIFICATION #:** 191-24-2/UN not available

**SYNONYMS:** 1,12-benzoperylene, B(g,h,i)P

**PHYSICAL PROPERTIES:** large, pale yellow-green plates; considered to be a polynuclear aromatic hydrocarbon; MP (277-279°C); BP (550°C); VP ( $\sim 10^{-10}$  torr @ 20°C); solubility in water (0.00026 mg/L @ 25°C); Log Kow (7.23); H ( $1.65 \times 10^{-6}$  atm-m<sup>3</sup>/mole @ 25°C)

**CHEMICAL PROPERTIES:** stable; oxidation to quinones and carboxylic acids

**BIOLOGICAL PROPERTIES:** Koc (calculated range):  $9 \times 10^4$  to  $4 \times 10^5$ ; highly immobile in soil; biodegradation half-life in aerobic soil: 600-650 days; can be detected in water by EPA Methods 610 and 625: gas chromatography or high performance liquid chromatography, or gas chromatography plus mass spectrometry

**BIOACCUMULATION:** has the potential to bioconcentrate in aquatic organisms, but is short-term

**ORIGIN/INDUSTRY SOURCES/USES:** found in motor-oil, crude oil, and gasoline; small amounts used for scientific research; product of combustion

**TOXICITY:** data not available

**EXPOSURE ROUTES:** most probably is occupational exposure; dermal contact; inhalation; natural fires; petroleum refining; coal tar distillation; combustion of wood, coal, oil, propane, gasoline, and diesel fuels; industrial effluents; municipal wastewater treatment facilities; waste incinerators; smoked and barbecued foods; contaminated drinking water supplies; recreation activities at contaminated waterways

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** ambient water concentration is 0; interim target risk level criteria considered by the EPA for  $10^{-5}$ ,  $10^{-6}$ , and  $10^{-7}$  ranges: 9.7 ng/L, 0.97 ng/L, and 0.097 ng/L respectively

**PROBABLE FATE:** *photolysis:* the dissolved portion could undergo rapid photolysis, but very little compound is present in the dissolved form; vapor phase reaction with photochemically produced hydroxyl radicals (half-life: 2 hr) may be an important fate process, may undergo direct photolysis in the atmosphere, photolytic half-lives adsorbed onto silica gel, alumina, fly ash, and carbon black: 7,22,29,>1000 hrs respectively; *oxidation:* oxidation by chlorine and/or ozone could occur if enough chlorine or ozone is present, but is relatively unimportant; *hydrolysis:* not expected to hydrolyze; *volatilization:* probably too slow to compete with adsorption as a

transport process, volatilization from shallow, fast moving water may be important, volatilization half-life from a model river and a model pond (considering effects of adsorption): 38 days and >1500 yrs respectively; **sorption**: very strong adsorption onto suspended solids, especially organic matter, is expected to be the dominant transport process; **biological processes**: bioaccumulation is short-term, metabolization and microbial degradation are the principal fates, biodegrades slowly in the environment

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 550; *Sedimentation*, >71, <10; *Powdered activated carbon adsorption* (based on synthetic wastewater), 83, 0.015

**KEY REFERENCES**: 23; 24; 25; 28; 30

### 3,4-BENZOFLUORANTHENE (C<sub>20</sub>H<sub>12</sub>, 252.3)

**CAS/DOT IDENTIFICATION #**: 205-99-2/UN

**SYNONYMS**: Benzo(b)fluoranthene, B(b)F, Benz(e)acephenanthrylene, 2,3-benzofluoranthene, Benzo[e]fluoranthene, B[E]F

**PHYSICAL PROPERTIES**: yellow, fluffy powder; insoluble in water; slightly soluble in benzene; MP (167-168°C); BP (357°C); Log Kow (6.57)

**CHEMICAL PROPERTIES**: oxidation to quinones and carboxylic acids; stable; can react with strong oxidizers; ozone and chlorinating agents oxidize this type of compound, may react with various electrophiles, peroxides, nitrogen oxides and sulfur oxides

**BIOLOGICAL PROPERTIES**: groundwater: 0.6-5.7  $\mu\text{g/m}^3$ ; tapwater: 2.6-5.4  $\mu\text{g/m}^3$ ; found in rivers in West Germany; primary and digested raw sewage sludge: 0.21-0.42 ppm; liquors from sewage sludge heat treatment plants: 0.03-0.55 ppm; sludge cake from heat treatment plants: 0.22-0.52 ppm; final effluent of sewage works: 0.03 ppb; aerobic half-life: 360 days-1.67 years; anaerobic half-life: 3.95-6.68 yrs; can be detected in water by EPA Methods 610, 625, and 1625: gas chromatography or high liquid chromatography, or gas chromatography and mass spectrometry

**BIOACCUMULATION**: bioconcentration in fish will occur, however fish will rapidly metabolize it by the action of the enzyme microsomal oxidase

**ORIGIN/INDUSTRY SOURCES/USES**: formed during incomplete burning of fossil fuel, garbage, or any other organic matter; smoke; component of coal tar pitch; binder for electrodes; component of creosote used to preserve wood; research chemical

**TOXICITY**: no data available

**EXPOSURE ROUTES**: inhaling tobacco smoke; accidental ingestion of contaminated soil or dust particles; consumption of contaminated water, fish, and shellfish, contact of soil near a hazardous waste site; contact with heavy oils containing the compound

**REGULATORY STATUS**: **Criterion to protect freshwater aquatic life**: insufficient data; **Criterion to protect saltwater aquatic life**: insufficient data; **Criterion to protect human health**: concentration calculated to keep the lifetime cancer risk level below  $10^{-5}$ ,  $10^{-6}$ , and  $10^{-7}$  is 28, 2.8, and 0.28 ng/L, respectively; Kansas has set guidelines in drinking water at 0.029  $\mu\text{g/L}$

**PROBABLE FATE:** *photolysis*: dissolved portion should undergo direct photolysis to quinones, atmospheric and aqueous photolytic half-life: 8.7-720 hrs, adsorbed compound may not photolyze significantly; *oxidation*: rapid oxidation by chlorine and ozone would occur when chlorine and ozone are sufficiently available, photooxidation half-life in air: 1.43-14.3 hrs; *hydrolysis*: not an important process; *volatilization*: expected to be too slow to compete with adsorption as a transport process; *sorption*: very strong adsorption onto suspended solids is the principal transport process, when released to water; adsorption to suspended sediments is expected to remove most of the compound; *biological processes*: short-term bioaccumulation accompanied by metabolization; biodegradation is the principal fate; release to soil results in some biodegradation

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): Sedimentation, 83, 6; *Aerated lagoons*, 0.4, 97; *Powdered activated carbon adsorption* (based on synthetic wastewater), 68, 0.040; *Ozonation*, >80, <0.02; *Chlorination*: 6 mg/L chlorine for 6 hr: initial concentration 5.18 ppb: 34% reduction

**KEY REFERENCES:** 21; 23; 24; 25; 26; 28; 30

### **BENZO (k) FLUORANTHENE (C<sub>20</sub>H<sub>12</sub>, 252.32)**

**CAS/DOT IDENTIFICATION #:** 207-08-9/UN not available

**SYNONYMS:** 8,9-benzofluoranthene, 11,12-benzofluoranthene, 11,12-benzo (k) fluoranthene, 2,3,1',8-binaphthylene, dibenzo (b, jk) fluorene, B (k) F, BKF

**PHYSICAL PROPERTIES:** pale, yellow crystals; soluble in benzene and acetic acid; considered a polynuclear aromatic hydrocarbon; MP (217°C); BP (480°C); solubility in water (<1 mg/mL @ 20°C); VP ( $9.59 \times 10^{-11}$  mmHg @ 25°C); Log Kow (6.06)

**CHEMICAL PROPERTIES:** oxidized by ozone and chlorinating agents; may react with various electrophiles, peroxides, nitrogen oxides, and sulfur oxides; can react with strong oxidizers

**BIOLOGICAL PROPERTIES:** not expected to leach into groundwater; can be transported long distances; will get into surface water by dust and precipitation in addition to runoffs and effluents; aerobic half-life: 2.49-5.86 yrs; anaerobic half-life: 9.97-23.5 yrs; surface water half-life: 3.8-499 hrs; ground water half-life: 4.99-11.7 yrs; can be detected in water by EPA Methods 610 and 625: gas chromatography or high performance liquid chromatography, or gas chromatography plus mass spectrometry

**BIOACCUMULATION:** expected to bioconcentrate in fish and seafood

**ORIGIN/INDUSTRY SOURCES/USES:** found in bitumen, gasoline, and crude oil; air-borne coal tar emissions; emissions from car engines; no commercial uses

**TOXICITY:** data not available

**EXPOSURE ROUTES:** smoking, inhalation of polluted air; eating contaminated food with products of combustion or prepared by smoking or charcoal broiled; exposure from drinking water expected to be minor

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** ambient water concentration is 0; interim target risk level criteria considered by the EPA for  $10^{-5}$ ,  $10^{-6}$ , and  $10^{-7}$  ranges: 9.7 ng/L, 0.97 ng/L, and 0.097 ng/L respectively

**PROBABLE FATE:** **photolysis:** dissolved portion may undergo photolysis to quinones, potential for reaction with alkyl peroxy radicals and hydroperoxy radicals which are photochemically produced in humic waters, atmospheric and aqueous photolytic half-life: 3.8-499 hrs; **oxidation:** if chlorine and/or ozone is present in sufficient quantity, rapid oxidation should occur, photooxidation half-life in air: 1.1-11 hrs; **hydrolysis:** not an important process; **volatilization:** probably too slow to compete with adsorption as a transport process; **sorption:** dominant transport process, on land, it is strongly adsorbed to soil, remains in the upper soil layers, in water it will adsorb to sediments and particulate matter in the water column; **biological processes:** bioaccumulation is short-term accompanied by metabolization, microbial biodegradation is the dominant fate, biodegradation expected to be very slow (half-life: 2 yrs with acclimated microorganisms)

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Gravity oil separation*, not available, 150; *Filtration*, 0, negative removal; *Sedimentation*, >57->97, <5; *Granular activated carbon adsorption*, >80, <0.02; *Powdered activated carbon adsorption* (based on synthetic wastewater), 97, 0.013; *chlorination*, 6 mg/L chlorine for 6 hr, initial concentration: 68.74 ppb: 56% reduction; atmospheric losses are caused by *gravitational settling* and *rainout*

**KEY REFERENCES:** 23; 25; 24; 26; 28; 30

## **BERYLLIUM (Be, 9.01)**

**CAS/DOT IDENTIFICATION #:** 7440-41-7/UN 1567

**SYNONYMS:** beryllium metallic, beryllium 9, glucinium, glucinum, beryllium dust

**PHYSICAL PROPERTIES:** gray metal, close-packed hexagonal structure; hard-light metal; odorless; high permeability to x-rays; hard and brittle; soluble in acids (except nitric) and alkalis; insoluble in water; MP (1278°C); BP (2970°C); DN (1.8477); VP (1 mmHg @ 1520°C); Brinell hardness (60-125)

**CHEMICAL PROPERTIES:** similar chemical properties to aluminum; resistant to attack by acid due to the formation of a thin oxide film; finely divided or amalgamated metal reacts with HCl, dil  $\text{H}_2\text{SO}_4$ , and dil  $\text{HNO}_3$ ; attacked by strong bases with evolution of  $\text{H}_2$ ; resistant to oxidation at ordinary temperatures; high thermal conductivity; HC (0.437 cal/g°C @ 30°C); latent heat of fusion (3.5 kcal/mol)

**BIOLOGICAL PROPERTIES:** metal will precipitate from natural sulfates and carbonates; some compounds dissolve in water, but most settle to the bottom; most beryllium in soil does not move up to the surface or into the groundwater; beryllium compounds of very low water solubility appear to predominate in soils; highly persistent in water (half-life >200 days)

**BIOACCUMULATION:** Nitrate BCF: 100 under constant exposure; fish do not accumulate beryllium in their bodies from the surrounding water to any great extent, however, the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken; inhaled beryllium has initial pulmonary half-life of

0.5-6 months; a particulate residuum tends to remain in lungs for long periods; some accumulation in tracheobronchial lymph nodes; can be detected in water according to EPA by digestion followed by atomic absorption or by a calorimetric method or by inductively coupled plasma (ZCP) optical emission spectrometry

**ORIGIN/INDUSTRY SOURCES/USES:** natural occurrence in soil, minerals, rocks, coal, and volcanic dust; electrical components; tools; aircraft; missiles; satellites; metal-fabricating; molds for plastics; televisions; calculators; personal computers; x-ray machines; mirrors

**TOXICITY:** Marine waters should not exceed 1/100 of 96-hr LC<sub>50</sub> (1.5 ppm); Fathead minnow (*Pimephales promelas*) TLm: 150 µg/L/96-hr, soft water; more toxic in soft water than in hard water; high acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** occupational exposure, including where it is mines, processes, and converted into alloys and chemicals; inhalation of beryllium dust; inhalation of fumes from the burning of coal or fuel oil; tobacco smoke; ingestion of fruits and vegetables and water; fly ash through chimney stacks; electronic devices

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** 130 µg/L based on acute toxicity, 5.3 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** ; criterion is preferably 0; concentration calculated to keep the lifetime cancer risk level below 10<sup>-5</sup>: 0.037 µg/L; MCGL: 0.004 mg/L; MCL: 0.004 mg/L; HAL (child): 1-to10-day: 30 mg/L, longer term: 4 mg/L; USSR MAC: 0.0002 mg/L in water bodies used for domestic purposes; guidelines in drinking water set by Kansas and Rhode Island: 0.13 µg/L and 131 µg/L respectively

**PROBABLE FATE: photolysis:** no data found on photolysis of beryllium; **oxidation:** not an important process; **hydrolysis:** soluble beryllium salts are hydrolyzed to form insoluble beryllium hydroxides; **volatilization:** airborne dusts are the most widely known hazard associated with beryllium; **sorption:** no data found on adsorption of beryllium **biological processes:** only slightly bioaccumulated

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 2; *Filtration*, 29-71, 1.6; *Sedimentation*, >87->98, <10; *Sedimentation with chemical addition (Fe<sup>2+</sup>, lime)*, >82->89, <0.5; *Sedimentation with chemical addition (alum)*, 0, negative removal; *Sedimentation with chemical addition (lime)*, 38-76, 0.85; *Aerated lagoons*, >50, <1; *Granular activated carbon adsorption*, 0, negative removal; *Reverse osmosis*, >42->85, <2.8

**KEY REFERENCES:** 11; 19; 21; 23; 27; 29; 31

### alpha-BHC (C<sub>6</sub>H<sub>6</sub>Cl<sub>6</sub>, 290.82)

**CAS/DOT IDENTIFICATION #:** 319-84-6/UN 2811

**SYNONYMS:** 1-alpha,2-alpha,3-beta,4-alpha,5-beta,6-beta-hexachlorocyclohexane, benzene-trans-hexachloride, alpha-1,2,3,4,5,6-hexachlorocyclohexane, cyclohexane,1,2,3,4,5,6-hexachloror-,alpha-isomer, alpha-lindane, alpha-hch, alpha-hexachlorane; hexachlorocyclohexane

**PHYSICAL PROPERTIES:** monoclinic prisms; soluble in alcohol and benzene; MP (159-160°C); BP (288°C); DN (1.87 @ 20°C); VP (0.02 mmHg @ 20°C); solubility in water (2 mg/L @ 25°C); OT (0.088 ppm in water); Log Kow (3.80); H (1.06x10<sup>-5</sup> atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** stable

**BIOLOGICAL PROPERTIES:** Koc: 6463; may bind tightly to soil and sediments; slow leaching to groundwater if released to soil; aerobic half-life: 80-135 days; anaerobic half-life: 7-40 days; surface water half-life: 13.8-135 days; ground water half-life: 13.8-270 days; can be detected in water by EPA Methods 608: gas chromatography, Method 625: gas chromatography plus mass spectrometry, and Method 617: methylene chloride extraction followed by gas chromatography

**BIOACCUMULATION:** guppy: 140 (@ 10 and 50 µg/L), 250 (@ 800 µg/L), 599, and 706; short-necked clam: 161; golden orfe: 1216; carp: 330; brown trout: 605; will bioconcentrate slightly in fish and other aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES:** component of benzene hexachloride, bhc a former insecticide; small amounts may come from isomerization of lindane upon exposure to sunlight

**TOXICITY:** growth inhibition algae (*Scenedesmus acutus*): 500 µg/L in freshwater; EC<sub>50</sub> (*Daphnia*): 0.1 ppm, reproduction efficiency

**EXPOSURE ROUTES:** use as a pesticide; primarily through ingestion of contaminated food; found also in air, water, sediment, and soil; inhalation and dermal contact among workers

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** data not available; **Criterion to protect saltwater aquatic life:** data not available; **Criterion to protect human health:** ambient water criteria at a cancer risk level of 10<sup>-5</sup>: 92 ng/L; concentration calculated to keep the cancer risk level below 10<sup>-4</sup>, 10<sup>-5</sup>, and 10<sup>-6</sup>: 6x10<sup>-1</sup> µg/L, 6x10<sup>-2</sup> µg/L, and 6x10<sup>-3</sup> µg/L, respectively; drinking water unit risk: 1.8x10<sup>-4</sup> ug/L

**PROBABLE FATE:** **photolysis:** C-Cl bond photolysis can occur, not important in aquatic organisms, photooxidation half-life in air: 9.24-92.4 hrs, reported to photodegrade in water in spite of the lack of a photoreactive center; **oxidation:** not an important process; **hydrolysis:** very slow, not important, first-order hydrolytic half-life: 207 days, reaction with hydroxyl radicals in atmosphere has a half-life of 2.3 days; **volatilization:** may be an important process, however, information is contradictory, volatilization half-life from a model river: 6 days, half-life from a model pond considering effects of adsorption: 500 days, slow volatilization from water is expected with a rate dependent upon the rate of diffusion through air; **sorption:** important for transport to anaerobic sediments; **biological processes:** biodegradation is important; occurs slowly in aerobic conditions, occurs quickly and extensively in anaerobic conditions

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Filtration*, 38-77, 4; *Granular activated carbon adsorption*, >47, <1; *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 250; may be removed by *rain-out* and *dry deposition* in atmosphere

**KEY REFERENCES:** 11; 22; 23; 26; 28; 30; 32

**beta-BHC (C<sub>6</sub>H<sub>6</sub>Cl<sub>6</sub>, 290.82)****CAS/DOT IDENTIFICATION #:** 319-89-7/UN not available**SYNONYMS:** cyclohexane,1,2,3,4,5,6-hexa-chloro-,beta-isomer, 1-alpha,2-beta,3-alpha,4-beta,5-alpha,6-beta-hexachlorocyclohexane, beta-hch, beta-hexachlorobenzene, beta-hexachloran, beta-lindane**PHYSICAL PROPERTIES:** crystals; insoluble in water; soluble in 100% alcohol and chloroform; MP (312 °C); BP (60°C @ 50 mmHg); DN (1.89 @ 19°C); VP (0.005 mmHg @ 20°C); solubility in water (0.24 mg/L @ 25°C); Log Kow (3.78)**CHEMICAL PROPERTIES:** stable**BIOLOGICAL PROPERTIES:** found in ground water; aerobic half-life: 60-124 days; anaerobic half-life: 30-94 days; soil and surface water half-life: 13.8-124 days; ground water half-life: 13.8-248 days; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with electron specific detection, or EPA Method 625: gas chromatography plus mass spectrometry**BIOACCUMULATION:** data not available**ORIGIN/INDUSTRY SOURCES/USES:** formerly used in the USA as an insecticide**TOXICITY:** data not available**EXPOSURE ROUTES:** contaminated drinking water**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** ambient water quality criterion should be 163 ng/L based on a corresponding lifetime cancer risk below  $1 \times 10^{-5}$ ; a cancer risk level of 1 in 100,000 is imposed by a concentration of 0.123 µg/L; interim target risk levels criteria considered by EPA in the ranges of  $10^{-5}$ ,  $10^{-6}$ , and  $10^{-7}$ ; 28 ng/L, 2.8 ng/L, and 0.28 ng/L respectively; USSR MAC: 0.02 mg/L in water bodies used for domestic purposes, and 0 in water bodies used for fishery purposes**PROBABLE FATE:** **photolysis:** C-Cl photolysis can occur, not important in aquatic systems, photooxidation half-life in air: 9.24 hrs-3.85 days; **oxidation:** not an important process; **hydrolysis:** very slow, not important, first-order hydrolytic half-life: 207 days; **volatilization:** information is contradictory as to how important process is; **sorption:** important for transport to anaerobic sediments; **biological processes:** biodegradation could be important**TREATABILITY/REMOVABILITY (Process, Removable Range (%), Avg. Achievable Conc. (µg/L)):** *Filtration*, 21, 55; *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 200**KEY REFERENCES:** 11; 21; 23; 24; 26; 28; 30**delta-BHC (C<sub>6</sub>H<sub>6</sub>Cl<sub>6</sub>, 290.82)****CAS/DOT IDENTIFICATION #:** 319-86-8/UN not available

**SYNONYMS:** benzenehexachloride, delta- HCCH, delta-HCH, TBH, 1-alpha,2-alpha,3-alpha,4-beta,5-alpha,6-beta-hexachlorocyclohexane, delta-bhc, delta-lindane

**PHYSICAL PROPERTIES:** crystals or fine platelets; slightly musty odor; 95% soluble in ethanol; MP (138-139°C); BP (60°C @ 0.36 mmHg); VP ( $1.7 \times 10^{-5}$  Torr @ 20°C); solubility in water (31.4 mg/L); Log Kow (4.14)

**CHEMICAL PROPERTIES:** stable under normal lab conditions; if heated to decomposition in air, it emits highly toxic fumes of phosgene, and hydrogen chloride

**BIOLOGICAL PROPERTIES:** aerobic half-life: 40-100 days; anaerobic half-life: 30-100 days; soil and surface water half-life: 13.8-100 days; ground water half-life: 13.8-200 days; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with electron specific detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** data not available

**ORIGIN/INDUSTRY SOURCES/USES:** formerly used as an insecticide, benzene hexachloride

**TOXICITY:** data not available

**EXPOSURE ROUTES:** contaminated drinking water; rivers in Japan: found to contain levels ranging from 0-10 ng/L

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; a cancer risk level of 1 in 100,000 is imposed by a concentration of 0.123 µg/L; USSR MAC: 0.02 mg/L in water bodies used for domestic purposes, and 0 in water bodies used for fishery purposes

**PROBABLE FATE:** **photolysis:** C-Cl photolysis can occur, not important in aquatic systems, photooxidation half-life in air: 9.24 hrs-3.85 days; **oxidation:** not an important process; **hydrolysis:** very slow, not important, first-order hydrolytic half-life: 207 days; **volatilization:** information is contradictory as to how important process is; **sorption:** important for transport to anaerobic sediments; **biological processes:** biodegradation could be important

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), 0, not available

**KEY REFERENCES:** 11; 21; 23; 24; 26; 28; 30

### **GAMMA-BHC (C<sub>6</sub>H<sub>6</sub>Cl<sub>6</sub>, 290.82)**

**CAS/DOT IDENTIFICATION #:** 58-89-9/UN NA2761

**SYNONYMS:** lindane, aalindan, aficide, agrisol G-20, agroicide, agronexit, ameisenatod, ameisenmittel Merck, aparsin, aphtiria, aplidal, arbitex, BBH, Ben-Hex, bentox 10, γ -Benzene hexachloride, bexol, BHC, γ -BHC, celanex, chloresene, codechine, DBH, detmol-extrakt, detox 25, devoran, dol granule, drill tox-spezial aglukon, ENT 7796, entomoxan, exagama, forlin, gallogama, gamacid, gamaphex, gamene, Gamiso, gamma-col, gammahexa, gammahexane,

gammalin, gammopaz, HCCH, HCH, -HCH, heclotox, hexachloran,  $\gamma$ -hexachloran,  $\gamma$ -hexachlorane,  $\gamma$ -hexachlorobenzene, , 1- $\alpha$ ,2- $\alpha$ ,3- $\beta$ ,4- $\alpha$ ,5- $\alpha$ ,6- $\beta$ -Hexachlorocyclohexane, hexatox, hexicide, HGI, inexit, isotox, jacutin, kokotine, kwell, lendine, lentox, lidenal, lindagrain, lintox, milbol 49, mszycol, neo-scabidol, nexit, novigam, ovardziak, viton

**PHYSICAL PROPERTIES:** white powder; slight musty odor; insoluble in water; MP (112.5 °C); BP (323.4 °C @ 760 mmHg); DN (1.85 g/cm<sup>3</sup>); VP (9.4 x 10<sup>-6</sup> mmHg @ 20 °C); solubility in water (7.5 mg/L @ 25°C); OT (12 ppm); Log Kow (3.72)

**CHEMICAL PROPERTIES:** stable to heat, light, and oxidation; corrosive to metals; volatile in air; incompatible with strong oxidizing agents; nonflammable

**BIOLOGICAL PROPERTIES:** anarobe bacteria: up to 90% degraded in 4 days, transformed to chlorine-free metabolites; a mixed culture of bacteria with *Pseudomonas aeruginosa* as a main component showed isomerization of gamma-HCH and alpha-HCH and metabolization to gamma-2,3,4,5,6-pentachlorocyclohexane and tetrachlorobenzene and unknown nonpolar metabolites; transport to sediment will be slow; slowly biodegrades in aerobic media and quickly degrades under anaerobic conditions; soil and surface water half-lives: 13.8-240 days; ground water half-life: 5.9-240 days; aerobic half-life: 31-413 days; anaerobic half-life: 5.9-30 days; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with electron capture or halogen specific detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** will bioconcentrate in fish; decapod (*Penaeus duorarum*): 96 hr @ 0.19-0.68  $\mu$ g/L: 51-142X; decapod (*Penaeus duorarum*): 96 hr @ 0.13-0.62  $\mu$ g/L: 32-143X; BCF (oysters): 60X; pelecypod (*Mytilus edulis*): 50 hr @ 1.24-2.29  $\mu$ g/L: 100X; fish (*Lagodon rhomboides*): 96 hr @ 32-91.3  $\mu$ g/L: 308-554X; fish (*Lagodon rhomboides*): 96 hr @ 18.4-31.3  $\mu$ g/L: 167-287X

**ORIGIN/INDUSTRY SOURCES/USES:** Used as an insecticide on field crops, corn wheat, ornamentals, pasture, forage crops, forestry, timber protection, livestock, soil and seed treatment, viticulture; treatment of head and body lice and scabies; medication

**TOXICITY:** Crustaceans: (*Gammarus lacustris*, *Gammarus fasciatus*, *Asellus brevicaudus*): 96 hr LC50: 48, 10, and 10  $\mu$ g/L respectively; Crustaceans: (*Simocephalus serrulatus*, *Daphnia pulex*): 48 hr LC50: 520 and 460  $\mu$ g/L respectively; fish: (catfish, bullhead, goldfish, minnow, carp, sunfish, bluegill, bass, rainbow, brown, coho, perch): 96 hr LC50: 44, 64, 131, 87, 90, 83, 68, 32, 27, 2, 41, and 68  $\mu$ g/L respectively; and many others in the references below

**EXPOSURE ROUTES:** oral ingestion of food; skin adsorption; skin and eye contact; released in air during formulation; wind erosion of contaminated soil; release from hazardous waste sites; groundwater; surface water in hazardous waste sites

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.080  $\mu$ g/L/24 hr avg., concentration not to exceed 2.0  $\mu$ g/L any time; **Criterion to protect saltwater aquatic life:** concentration not to exceed 0.16  $\mu$ g/L any time; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 0.186  $\mu$ g/L; Mexico set allowable limits in coastal waters and in estuaries of 0.2  $\mu$ g/L and 2.0  $\mu$ g/L respectively; WHO: 3.0  $\mu$ g/L in drinking water; long term health advisory by the EPA: 120  $\mu$ g/L; lifetime health advisory: 2  $\mu$ g/L for adults; Maine set a guideline in drinking water of 4.0  $\mu$ g/L; maximum level in drinking water posed by EPA: 0.2  $\mu$ g/L

**PROBABLE FATE:** *photolysis:* C-Cl bond photolysis can occur, not important in aquatic systems, photooxidation by U.V. light in aqueous medium @ 90-95°C, time for the formation of CO<sub>2</sub> (% theoretical): 24%: 3 hr, 50%: 17.4 hr, 75%: 45.8 hr, photooxidation in air: 9.24 hrs-3.85 days; *oxidation:* probably not an important process; *hydrolysis:* very slow, not important, first-order hydrolytic half-life: 207 days; *volatilization:* not an important process, calculated half-life in water: 4590 hr @ 25°C and 1 m depth, based on an evaporation rate of  $1.5 \times 10^{-4}$  m/hr; *sorption:* important for transport to anaerobic sludges, 30-40% adsorbed on aquifer sand @ 5°C after 3-100 hr equilibrium time, 75-100% disappearance from soils: 3-10 yrs; *biological processes:* biotransformation is the most important process; *other reactions/interactions:* electrochemical reduction with products of benzene and gamma-TCCH has been studied

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 6; *Continuous activated sludge biological treatment simulator:* 25% removal

**KEY REFERENCES:** 11; 19; 21; 23; 25; 26; 30

### BIS (2-CHOROETHOXY) METHANE (C<sub>5</sub>H<sub>10</sub>Cl<sub>2</sub>O<sub>2</sub>, 173.1)

**CAS/DOT IDENTIFICATION #:** 111-91-1/UN 2810

**SYNONYMS:** dichloroethyl formal, dichlorodiethyl formal, bis (beta-chloroethyl) formal, formaldehyde bis (beta-chloroethyl) acetal, dichlorodiethyl methylal, BCEXM

**PHYSICAL PROPERTIES:** colorless liquid; slightly soluble in water; MP (-32.8°C); BP (218.1°C); SG (1.2339); VP ( $1.4 \times 10^{-4}$  mmHg @ 25°C); solubility in water ( $8.1 \times 10^4 - 1.2 \times 10^5$  mg/L @ 25°C); Log Kow (1.26); H ( $1.7 \times 10^{-7}$  atm-m<sup>3</sup>/mol @ 25°C)

**CHEMICAL PROPERTIES:** not flammable; incompatible with oxidizing materials; unstable; FP (110°C)

**BIOLOGICAL PROPERTIES:** Koc (7-115); if released on soil, expected to have high to very high mobility; if released to water, reported as undergoing 0% biodegradation using settled domestic wastewater as an inoculum, biodegradation remained at 0% through three sub-cultures; when the influent to a full scale activated sludge treatment system was spiked with 0.24 µg/L, 60% of the pollutant was removed, but not reported as to which removal process was used; can be decomposed by mineral acids; decomposition in highly acidic waters might be a method for degradation; would not be expected to biodegrade; can be detected in water by EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** bioconcentration factors are in the range of 0.84-2.2, using regression equations; bioconcentration in aquatic organisms should not be an important fate process; pollutant was not found in a wide variety of fish collected from fourteen Lake Michigan tributaries and embayments

**ORIGIN/INDUSTRY SOURCES/USES:** anthropogenic compound, not believed to occur in nature; synthetic compound; solvent; intermediate for polysulfide rubber; treatment of textiles; manufacture of polymers and insecticides; degreasing agents; preparation of ion exchange resins

**TOXICITY:** data not available

**EXPOSURE ROUTES:** dermal contact and inhalation during manufacture and formulation in polymers; during use as a solvent

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** insufficient data

**PROBABLE FATE:** *photolysis:* direct photochemical degradation in the atmosphere or in the upper layers of surface waters should not be an important fate process; half-life for the atmospheric reaction with photochemically produced hydroxyl radicals: 10 hrs; *oxidation:* could occur, but too slow to be important; *hydrolysis:* gradual hydrolysis of carbon-chlorine bond is a probable principle fate mechanism, can be expected in comparison to other chlorine containing compounds, half-life for this pH independent process: 0.5-2 yrs; *volatilization:* not important, volatilization from water should be a slow process; half-life from a model pond: 11 yrs, volatilization from the soil to the atmosphere might occur, but will be a slow process, volatilization from moist soil should not be an important fate process; *sorption:* possible importance as catalyst for hydrolysis; *biological processes:* biodegradation not expected to be an important fate process, but there is not enough data to draw a conclusion

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Aerated lagoons*, >60, <10; *Aerated lagoons* (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption* (based on synthetic wastewater), 97, 1800; *rain washout* may be an important fate process because of its high water mobility

**KEY REFERENCES:** 21; 22; 23; 28; 30

## **BIS (2-CHLOROETHYL) ETHER (C<sub>4</sub>H<sub>8</sub>Cl<sub>2</sub>O, 143.02)**

**CAS/DOT IDENTIFICATION #:** 111-44-4/UN 1916

**SYNONYMS:** bb-dichloroethylether, sym-dichloroethylether, 2,2'-dichloroethylether, 1-chloro-2-(b-chloroethoxy)ethane; BCEE, dichloroethyl ether

**PHYSICAL PROPERTIES:** colorless liquid; nauseating odor, similar to ethylene dichloride; insoluble in water; soluble in Et<sub>2</sub>O, MeOH, and C<sub>6</sub>H<sub>6</sub>; MP (-50°C); BP (178°C); SG (1.22); VP (0.71 mm @ 20°C); VD (4.93); solubility (10,200 mg/L); OT (0.049 ppm); Log Kow (1.58); refractive index (1.4575 @ 20°C)

**CHEMICAL PROPERTIES:** reacts vigorously with oleum, chlorosulfonic acid, and oxidizing materials; nonflammable; FP (131°F); AT (696°F); LEL (2.7%)

**BIOLOGICAL PROPERTIES:** TOC: 0.36 mg/L; Koc (1.38); highly mobile in soil; moderately persistent in water (half-life: 20-200 days); expected to leach extensively into groundwater; aerobic half-life, soil, and air half-lives: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months; ground water half-life: 8 weeks-12 months; can be detected in water by EPA Method 611: methylene chloride extraction followed by gas chromatography with halogen specific detector, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** bioconcentration in aquatic organisms is extremely low; concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** fumigants; processing fates, waxes, greases, cellulose esters; general solvent; insecticide; textile manufacturing and cleaning; manufacture of butadiene; medicinals; pharmaceuticals; constituent in paints, lacquers, and varnishes; formed by chlorination of drinking water when ethyl ether is present

**TOXICITY:** concentration causing adverse taste in fish: 1.0 mg/L; slight acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** ambient air; drinking water supplies; groundwater near waste disposal sites; chemical plants where sym-dichloroethyl ether is manufactured or used; industrial effluents

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 238,000 µg/L for chloroalkyl ethers in general; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** criterion is preferably 0; lifetime cancer risk level of 1 in 100,000 is posed by a concentration of 0.3 µg/L; the following are standards and guidelines in drinking water set by some states: 0.31 µg/L (Minnesota), 4.2 µg/L (Kansas), 8.3 µg/L (Maine), 10 µg/L (Arizona); ambient water quality criterion for 10<sup>-6</sup> risk level: 0.030 µg/L, assuming a person consumes 2L water and 6.5g fish/shellfish per day

**PROBABLE FATE:** **photolysis:** aqueous photolysis is not expected to be important, reaction with photochemically produced hydroxyl radicals has a half-life of 13.44 hr, direct photolysis is not expected to be important since it should not adsorb wavelengths >290 nm; **oxidation:** photooxidation is not expected to be important, photooxidation only in atmosphere, photooxidation half-life in air: 9.65 hrs-4.02 days; **hydrolysis:** very slow, maybe significant, hydrolysis of carbon-chloride bonds, release to water results in hydrolysis with a half-life of 40 days; when released to soil, it may hydrolyze; hydrolyzed slowly in aqueous dimethylformamide at pH 7, first-order hydrolytic half-life: 22yrs; **volatilization:** expected to volatilize if released to water, volatilization half-lives from lakes, rivers, and streams: 3.5, 4.4, and 180.5 days respectively; **sorption:** not an important process; **biological processes:** biodegrades in water after several weeks of acclimation, biodegradation not important under natural conditions, no bioaccumulation noted

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge*, >47, <10; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption*, 53, 44; *Powdered activated carbon adsorption* (based on synthetic wastewater), 53, 24000; *conventional municipal treatment:* influent: 0.55mg/l, effluent: 0.010mg/L, therefore, 82% removal

**KEY REFERENCES:** 19; 20; 21; 22; 23; 25; 26; 27; 28; 30

## **BIS (2-CHLOROISOPROPYL) ETHER (C<sub>6</sub>H<sub>12</sub>Cl<sub>2</sub>O, 171.1)**

**CAS/DOT IDENTIFICATION #:** 108-60-1/UN 2490

**SYNONYMS:** BCIE, dichloroisopropyl ether, bis(2-chloro-1-methylethyl)-ether, BCME; DCIP; 2,2-oxybis(1-chloropropane), nemamort

**PHYSICAL PROPERTIES:** colorless liquid; miscible in organic solvents and most oils; soluble in ether, benzene and alcohol; MP (-97°C); BP (189°C); SG (1.11); VP (0.85 @ 20°C); VD (6.0); solubility in water (1700 mg/L); VS (0.0230 poise @ 20°); OT (200µg/L); Log Kow (2.58); refractive index (1.4505 @ 20°C)

**CHEMICAL PROPERTIES:** incompatible with strong oxidizing materials; combustible; FP (85°C)

**BIOLOGICAL PROPERTIES:** Koc: 73; high mobility in soil; long distance transport in water systems is expected to be significant; will leach significantly into groundwater if released to soil; may persist in groundwater for a long period of time; biodegradation in soil may be slow; first-order reduction in concentration gives half-lives of 3-30 days in river water, and 30-300 days in lake and groundwater; soil, surface water, and aerobic half-lives: 18 days-6 months; ground water half-life: 36 days-12 months; anaerobic half-life: 72 days-24 months; can be detected in water by EPA Method 611: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** bioconcentration in aquatic organisms is not expected to be significant

**ORIGIN/INDUSTRY SOURCES/USES:** solvent; organic chemicals industry; constituent in waterborne wastes from propylene glycol manufacture; processing fats, waxes, greases; textile manufacturing; cleaning solution; intermediate in synthesis; extractant; paint and varnish; spotting agents; nematocide in Japan; fungicidal preparations; insecticidal wood preservative

**TOXICITY:** data not available

**EXPOSURE ROUTES:** waste streams from propylene glycol production; consumption of contaminated drinking water; occupational settings; inhalation of vapors; eye and skin contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 238,000 µg/L based on acute toxicity for chloroalkyl ether in general; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** ambient water criterion: 34.7 µg/L; drinking water guideline set by Kansas: 34.7 µg/L

**PROBABLE FATE:** **photolysis:** direct photolysis is probably not important, if released to atmosphere, will degrade by reaction with photochemically produced hydroxyl radicals (estimated half-life: 1.15 days); **oxidation:** photooxidation in atmosphere can occur, photooxidation half-life in air: 4.61-46.1 hrs; **hydrolysis:** slow hydrolysis of carbon-chlorine bond, may be important fate mechanism; **volatilization:** if released to water, volatilization is expected to be the principle removal process, but may be slow, volatilization half-lives for a model river (1 m deep) and a model environmental pond: 13.9 hr, and 6.6 days respectively; **sorption:** adsorption on organic matter is possible; **biological processes:** no data on bioaccumulation or biodegradation

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge*, ~100, <50; *Powdered activated carbon adsorption*, 87, 6200; *Aerated lagoons*, >0, <2; *conventional municipal treatment:* influent: 0.024 mg/L, effluent: not detected

**KEY REFERENCES:** 21; 23; 25; 26; 28; 30

**BIS (2-ETHYLHEXYL) PHTHALATE (C<sub>24</sub>H<sub>38</sub>O<sub>4</sub>, 390.62)**

**CAS/DOT IDENTIFICATION #:** 117-81-7/UN not available

**SYNONYMS:** BEHP, bis(2-ethylhexyl)-1,2-benzenedicarboxylate, bisoflex 81, bisoflex DOP, DAF 68, DEHP, DOP, ergoplast FDO, ethylhexyl phthalate, 2-ethylhexyl phthalate, eviplast 80, eviplast 81, fleximel, flexol DOP, flexol plasticizer DOP, hatcol DOP, octoil, truflex DOP, vestinol, vinicizer 80

**PHYSICAL PROPERTIES:** colorless liquid with almost no odor; MP (-50°C); BP (384°C); DN (0.981); VP (6.2x10<sup>-8</sup> mmHg @ 25°C); solubility (0.1 g/l @ 20°C); VS (80 cP @ 20°C); Log Kow (4.2-5.11)

**CHEMICAL PROPERTIES:** stable under normal temperature and pressure; incompatible with strong oxidizers, strong acids, and strong alkalies; FP (199°C); AT (390°C); LEL (10%)

**BIOLOGICAL PROPERTIES:** Log Koc values: 4-5; strong partitioning to clays and sediments; strong tendency to adsorb to sediments and soil; biodegrades rapidly under aerobic conditions following acclimation in screening biodegradation tests, river, lake water, water/sediment systems, and in activated sludge; aerobic degradation in fresh water hydrosol: 50% after 14 days incubation; biodegradation in river water, 1 week: 10%; after 30 days in fresh water hydrosol under aerobic conditions: 56%; degradation in the water of a model ecosystem half-life: 5 days; soil, surface water, and aerobic half-lives: 5-23 days; anaerobic half-life: 42-389 days; ground water half-life: 10-389 days; activated sludge half-life: 0.8 days; can be detected in water by EPA Method 606: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** Algae (*Oedogonium*): after 33 days in model ecosystem, water contained 0.00034 ppm, algae contained 18.32 ppm, BCF (55.890); less than 2% (0.16 ppm) of that accumulated by the water flea (*Daphnia*) was present as the unmetabolized ester; Mollusca (*Physa*): after 33 days in model ecosystem, water contained 0.00034 ppm, snail contained 7.30 ppm, BCF (21,480); Fish (*Gambusia affinis*): after 33 days in model ecosystem, water contained 0.00034 ppm, fish contained 0.044 ppm, BCF (130); BCF (mosquito fish, after 3 days and after 33 days): 1.16, 9400; BCF (algae, after 3 days and 33 days): 660, 285000; Log BCF (fish and invertebrates experimental values): 2, 5, 32, 35, 45, 49, and 57; Log BCF (fathead minnows): 2.93, Log BCF (bluegill sunfish): 2.06

**ORIGIN/INDUSTRY SOURCES/USES:** used in the production of polyvinyl chloride; added to plastics to make them flexible; liquid used in vacuum pumps; organic chemical industry; recycling and processing plastics; organic pump fluid

**TOXICITY:** larvae of grass shrimp (*Palaemonetes Pugio Holthius*): no significant increase in mortality at 1 ppm after 26 days

**EXPOSURE ROUTES:** most probable through food; plastics during processing and storage; blood transfusions; kidney dialysis; use of respirators; drinking water; ambient air; air in newly painted room; air in room with recently installed flooring; factories that manufacture or use DEHP; inhalation; ingestion; skin and eye contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** ambient water criterion: 15 mg/L; a no-adverse affect level in drinking water calculated by NAS/NRC: 4.2 mg/L; acceptable daily intake (ADI): 0.6 µg/kg/day calculated by NAS/NRC; EPA proposed a limit of 6 ppb of drinking water

**PROBABLE FATE:** *photolysis*: no direct photolysis, indirect photolysis is too slow to be important, atmospheric and aqueous photolytic half-life: 144-200 days; *oxidation*: not an important process, photooxidation half-life in water: 44-584 days, photooxidation half-life in air: 2.9-29 hrs; *hydrolysis*: too slow to be important (half-life of several years); *volatilization*: not a likely transport process, should not evaporate from soil or water; *sorption*: sorption onto particles and biota and complexation with humic materials are most important transport processes, attaches strongly to soil particles; *biological processes*: bioaccumulation and metabolization by many organisms, and biodegradation are all very important fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 270; *Gas flotation*, 0, negative removal; *Gas flotation with chemical addition (calcium chloride polymer)*, 77-82, 610; *Gas flotation with chemical addition (polymer)*, 51-92, 60; *Gas flotation with chemical addition (alum, polymer)*, 25, 90; *Filtration*, 44-98, 1200; *Sedimentation*, 33->99, 24; *Sedimentation with chemical addition (alum, lime)*, 0, negative removal; *Sedimentation with chemical addition (lime, polymer)*, 44-99, 22; *Sedimentation with chemical addition (polymer)*, >48->97, <10; *Sedimentation with chemical addition (BaCl<sub>2</sub>)*, 48-95, 9; *Sedimentation with chemical addition (alum, polymer)*, 78, 67; *Sedimentation with chemical addition (alum)*, 0, negative removal; *Tertiary polishing lagoons*, >58-72, <11; *Aerated lagoons*, 70-96, <11; *Trickling filters*, 83, 6; *Ozonation*, 0, negative removal; *Activated sludge*, 37->99, 64; *Powdered activated carbon adsorption*, >97, <10; *Granular activated carbon adsorption*, 18-66, 65; *Reverse osmosis*, 51-96, 21; can be removed by rain

**KEY REFERENCES:** 19; 21; 22; 23; 25; 26; 29

### BROMOFORM (CHBr<sub>3</sub>, 252.75)

**CAS/DOT IDENTIFICATION #:** 75-25-2/UN 2515

**SYNONYMS:** methyl tribromide, tribromomethane

**PHYSICAL PROPERTIES:** colorless to pale yellow liquid; sweetish odor; sweetish taste; slightly soluble in water; soluble in benzene, chloroform, alcohol, ether, solvent naphtha, fixed and volatile oils; freezes to hexagonal crystals; MP (8.3°C); BP (149°@ 15 mmHg); DN (2.8899 g/mL @ 20°C); VP (5 mmHg @ 20°C); VD (8.7); ST (41.53 dynes/cm @ 20°C); OT (1.3 ppm); solubility in water (3010 g/mL @ 15°C); HV (9673.3 gcal/gmol); Log Kow (2.38); H (0.532x10<sup>-3</sup> atm-m<sup>3</sup>/mole); refractive index (1.5976 @ 20°C)

**CHEMICAL PROPERTIES:** gradually decomposes, acquiring yellow color; attacks some forms of plastics, rubber, and coatings; solidifies @ 7.5°C; incompatible with metals, strong oxidants, bases, lithium, and sodium-potassium alloy; nonflammable

**BIOLOGICAL PROPERTIES:** nonbiodegradable in water; release to soil will result in leaching to groundwater due to weak adsorption to soil; anaerobic biodegradation will occur, but aerobic is expected to be insignificant; soil half-life: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months; ground water half-life: 8 weeks-12 months; can be detected in water by EPA Method 601: gas chromatography, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF(estimated in fish): 37.4; the concentration found in fish tissues is expected to be somewhat higher than the concentration found in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** formed during the chlorination of water; used as a solvent in waxes, greases, oils, liquid-solvent extractions; nuclear magnetic resonance studies; pharmaceuticals; fire-resistant chemicals; gauge fluid; reagent for graphite; ore faction; cough suppression agent; shipbuilding; aircraft; aerospace industries; medication; sedative; anti-septic; vulcanization of rubber; used in polymer reactions as a catalyst, sensitizer, and indicator

**TOXICITY:** larvae of eastern oyster (*Crassostrea virginica*): LC<sub>50</sub>, 48 hr: 1 mg/L, initial conc., static test (after 48 hr, only about 30% of original conc. was still present); bluegill sunfish (*Lepomis macrochirus*), LC<sub>50</sub>: 29,300 mg/L/96-hr static bioassay; mysid shrimp (*Mysidopsis bahia*), LC<sub>50</sub>: 24,400 mg/L/96-hr static bioassay; sheepshead minnow (*Cyprinodon variegatus*), LC<sub>50</sub>: 17,900 mg/L/96-hr static bioassay; moderate acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** drinking water that has been disinfected with bromine or bromine compounds; swimming pools; inhalation of evaporated bromoform near pools; through skin from water; inhalation of ambient air near factories and laboratories; near a chemical waste site where bromoform leaked into soil or water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 840 µg/L/24 hr avg., concentration not to exceed 1900 µg/L any time; **Criterion to protect saltwater aquatic life:** 180µg/L/24 hr avg., concentration not to exceed 420 µg/L any time; **Criterion to protect human health:** 2 µg/L or preferably 0; lifetime cancer risk level of 1 in 100,000: 1.9 µg/L; EPA proposed a maximum concentration in drinking water: 0.100 mg/L; Illinois and Maryland set guidelines in drinking water of 1.0 µg/L and 40 µg/L respectively

**PROBABLE FATE:** **photolysis:** could be important, photooxidation half-life in water: 54.1-541 days, direct photolysis in the stratosphere may occur, but is insignificant in the troposphere, reaction with photochemically produced hydroxyl radicals yields a half-life of 1.45 yrs; **oxidation:** atmospheric photooxidation by hydroxyl radicals to COBr<sub>2</sub> is relatively rapid; **hydrolysis:** too slow to be important, first-order hydrolytic half-life: 687 yrs; **volatilization:** volatilization has been demonstrated, could be an important transport process, volatilization from moist soil surfaces expected to occur; **sorption:** no information is available; **biological processes:** slight potential for bioaccumulation/metabolization is known to occur in some organisms; **other reactions/interactions:** possibly produced by halogen reaction

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), 48, 2600; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 13; *continuous activated sludge biological treatment simulator*, 68% removal

**KEY REFERENCES:** 11; 19; 21; 23; 24; 25; 26; 27; 28; 30

#### 4-BROMOPHENYL-PHENYLETHER (BrC<sub>6</sub>H<sub>4</sub>OC<sub>6</sub>H<sub>5</sub>, 249.1)

CAS/DOT IDENTIFICATION #: 101-55-3/UN 2810

**SYNONYMS:** 1-bromo-4-phenoxybenzene; p-bromophenyl phenyl ether, 4-bromodiphenyl ether, 4-bromophenyl ether

**PHYSICAL PROPERTIES:** liquid; insoluble in water; soluble in ether; MP (18.7°C); BP (310°C); DN (1.4208 @ 20°C); SG (1.420); VD (8.61); VP (0.0015 torr @ 20°C); Log Kow (4.28); H ( $1.17 \times 10^{-4}$  atm-m<sup>3</sup>/mole); refractive index (1.6084 @ 20°C)

**CHEMICAL PROPERTIES:** incompatible with oxidizing agents; combustible; FP (>112°C)

**BIOLOGICAL PROPERTIES:** Koc: 17000; significant leaching is not expected to occur if released to soil; resistant to biodegradation based on only 1 study; can be detected in water by EPA Methods 611: methylene chloride extraction followed by gas chromatography with halide-specific detector, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (regression equation): 5690; significant bioconcentration on aquatic organisms is expected

**ORIGIN/INDUSTRY SOURCES/USES:** possibly formed during chlorination treatment of sewage and drinking water; formerly used as a flame retardant in polymers; heat exchange fluid; research chemical; not produced commercially in the USA

**TOXICITY:** LC50 (Water flea: *Daphnia magna*): 0.46 mg/L/24 hr, 0.36 mg/L/48 hr; LC50 (Bluegill: *Lepomis macrochirus*): 50.9 mg/L/24 hr, 9.6 mg/L/48 hr, 9.6 mg/L/72 hr, 4.9 mg/L/96 hr

**EXPOSURE ROUTES:** raw water; consumption of contaminated drinking water; river water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 6.2 µg/L/24-hr avg., concentration not to exceed 14 µg/L any time; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** insufficient data to develop a criterion

**PROBABLE FATE:** **photolysis:** could be important, it is adsorbed by sensitizer-containing humus, degrades quickly by photochemically produced hydroxyl radicals in the air, half-life: 1.3 days, indirect photolysis is considered to be too slow; **oxidation:** not an important process; **hydrolysis:** not an important process, it is considered to be unlikely that any of the covalent bonds will hydrolyze at ambient environmental conditions, since the negative charge-density of the aromatic ring will impede the nucleophilic attack of water or hydroxide ion; **volatilization:** expected to be unimportant, in the absence of adsorption, volatilization half lives for a model river and environmental pond: 16.5 and 185 hrs, respectively; **sorption:** adsorption by humus and probable adsorption to clays, may adsorb significantly to sediment or suspended material if released to water, sediment to water distribution ratio: 4:1 for 4-chlorophenyl phenyl ether during biodegradation studies with sludge; assumed to adsorb electromagnetic radiation in the ultraviolet region of the terrestrial solar spectrum; **biological processes:** bioaccumulation possible, gradual biodegradation probably the principle fate; not significantly degraded by activated sludge microbiota at concentrations of 5 mg/L and 10 mg/L; was not significantly biodegraded over 28 days

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Activated sludge*, 95, 18; *Activated sludge* (based on synthetic wastewater), 36, 3200; *Powdered activated carbon adsorption* (based on synthetic wastewater), 98, 240

**KEY REFERENCES:** 4; 14; 21; 23; 24; 28; 30

**BUTYLBENZYLPHTHALATE (C<sub>19</sub>H<sub>20</sub>O<sub>4</sub>, 312.39)**

**CAS/DOT IDENTIFICATION #:** 85-68-7/UN not available

**SYNONYMS:** BBP, benzyl butyl phthalate, n-butyl benzyl phthalate, santicizer 160, sicol 160, palatinol BB, unimol BB, 1,2-benzenedicarboxylic acid

**PHYSICAL PROPERTIES:** clear, oily liquid; slight odor; MP (-35°C); BP (370°C); SG (1.1); VP (8.6x 10<sup>-6</sup> mmHg @ 20°C); VD (10.8); solubility in water (2.0 mg/L); Log Kow (~5.8); H (1x10<sup>-6</sup> atm·m<sup>3</sup>/mole); Log Poct (4.78); refractive index (1.535-1.540 @ 25°C)

**CHEMICAL PROPERTIES:** combustible; incompatible with oxidizing materials; reacts with oxygen, peroxides, and nitrates; HC (-8090 cal/g); FP (199°C); AT (233°C); LEL (1.2% @ 233°C)

**BIOLOGICAL PROPERTIES:** Koc: 65-350; most releases will be to the soil and water, and not to air; not expected to leach into groundwater; readily biodegraded in activated sludge, semicontinuous activated sludge, salt water, lake water, and under anaerobic conditions; biodegradation by activated sludge measured by gas chromatography: 93-99%, in river water: 100%, lake water microcosm: >95%; aerobic half-life: 1-7 days; anaerobic half-life: 4 weeks-6 months; soil and surface water half-life: 1-7 days; ground water half-life: 2 days-6 months; primary degradation of 1 mg/L in lake water microcosm: 95% in 7 days, 51-65% after 28 days

**BIOACCUMULATION:** BCF (bluegill, based on carbon 14 determinations, after 21 days exposure at a concentration of 9.73 mg/L): 663, depuration half life: <2 days; uptake efficiency (english sole gills, after 3 hr exposure at 20-250 mg/L concentrations): 42.2%

**ORIGIN/INDUSTRY SOURCES/USES:** plasticizer for polyvinyl and cellulosic resins; organic intermediate

**TOXICITY:** algae (*Microcystis*): 96 hr LC50: 1000 mg/L, no effect concentration: 560 mg/L; mysid shrimp; 96 hr LC50: 0.9 mg/L, no effect concentration: 0.4 mg/L; fathead minnow: 96 hr LC50: 2.1-5.3 mg/L, no effect concentration: 1.0-2.2 mg/L; bluegill: 96 hr LC50: 1.7 mg/L, no effect concentration: 0.38 mg/L; rainbow trout: 96 hr LC50: 3.3 mg/L, no effect concentration: <0.36 mg/L; sheepshead minnow: 96 hr LC50: 3.0 mg/L, no effect concentration: 1.0 mg/L; fathead minnows: 4 d LC50: 2.32 mg/L

**EXPOSURE ROUTES:** manufacture, distribution, and PVC blending operations; release from consumer products is expected to be minimal; found in some drinking waters; workers; contact on skin

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** insufficient data

**PROBABLE FATE:** **photolysis:** direct photolysis is improbable, indirect photolysis is too slow to be important, aqueous photolytic half-life: 100 yrs; **oxidation:** could occur, but could probably not compete with degradation, photooxidation half-life in air: 2.5 days; **hydrolysis:** too slow to be important, half-life is greater than 100 days; **volatilization:** not expected to be a likely transport process, will volatilize under windy conditions or from shallow waters; **sorption:** sorption onto particulates and complexation with organic substances are dominant transport processes, expected to adsorb if released to soil; **biological processes:** bioaccumulated and metabo-

lized by many organisms, biodegraded under natural conditions, biodegradation is the primary fate mechanism

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gas flotation*, >99, not detected; *Gas flotation with chemical addition (calcium chloride, polymer)*, >99, <0.03; *Gas flotation with chemical addition (polymer)*, >99, <0.03; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, 76->99, 2.2; *Sedimentation*, >48->99, <11; *Sedimentation with chemical addition (lime, polymer)*, >99, <10; *Sedimentation with chemical addition (alum, polymer)*, 54, 36; *Aerated lagoons*, 0, negative removal; *Trickling filters*, 25, 6; *Ozonation*, >97, <0.03; *Activated sludge*, 0, negative removal; *Granular activated carbon adsorption*, >83->99, 5.7; *Powdered activated carbon adsorption* (based on synthetic wastewater), 94, 26

**KEY REFERENCES:** 21; 22; 23; 25; 26; 28; 30

## CADMIUM (Cd, 112.4)

**CAS/DOT IDENTIFICATION #:** 7440-43-9/UN 2570

**SYNONYMS:** Kadmium, Cadmium: C.I. 77180, Colloidal cadmium

**PHYSICAL PROPERTIES:** soft, silver-white metal; usually found in combination with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfide); malleable or powder; becomes brittle at 80 °C; MP (321°C); BP (765°C); DN (8.642); VP (negligible @ 25°C); solubility in water ( $\text{CdCl}_2$ :  $1.4 \times 10^6$  mg/L @ 20°C,  $\text{Cd}(\text{OH})_2$ : 2.6 @ 25°C mg/L); refractive index (1.13)

**CHEMICAL PROPERTIES:** tarnishes in moist air; corrosion resistance poor in industrial atmospheres; resistant to alkalis; lowers melting point of certain alloys when used in low percentages; combustible; flammable in powder form

**BIOLOGICAL PROPERTIES:** highly persistent in water, half-life: >200 days; can be detected in water by digestion followed by atomic absorption of chlorimetric analysis or by Inductively Coupled Plasma Optical Emission Spectrometry; dissolved form is detected by 0.45 $\mu$  filtration followed by the previous methods

**BIOACCUMULATION:** accumulates in the tissues of aquatic and marine organisms at higher concentration; the concentration found in fish tissues is expected to be much higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** electrodeposited and dipped coatings on metals; bearing and low metal alloys; brazing alloys; fire protection systems; nickel-cadmium storage batteries; power transmission wire; TV phosphors; basis of pigments in ceramic glazes; machinery enamels; baking enamels; Weston-standard-cell control of atomic fission in nuclear reactors; fungicide; photography and lithography; selenium rectifiers; electrodes for cadmium-vapor lamps and photoelectric cells; soft solder and solder for aluminum; deoxidizer in Ni plating; process engraving; powder used as an amalgam in dentistry; to charge Jones reducers; inhalation; ingestion

**TOXICITY:** not available

**EXPOSURE ROUTES:** primary source is burning of fossil fuels such as coal or oil; in-

cineration of municipal waste materials; from zinc, lead, or copper smelters; food; application of phosphate fertilizers; sewage sludge; soil; smoking, smokers have twice as much as nonsmokers; spills or leaks at hazardous waste sites; fish, plants, animals; breathing contaminated workplace air; drinking contaminated water

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:**  $\exp[1.05 \ln(\text{hardness}) - 8.53]$   $\mu\text{g/L}/24\text{-hr}$ , not to exceed  $\exp[1.05 \ln(\text{hardness}) - 3.73]$   $\mu\text{g/L}$  any time; **Criterion to protect saltwater aquatic life:** 4.5  $\mu\text{g/L}/24$  hr-avg., not to exceed 59.0  $\mu\text{g/L}$  any time; **Criterion to protect human health:** 10  $\mu\text{g/L}$ ; EPA proposed a limit in drinking water of 5  $\mu\text{g/L}$ ; Argentina and Japan effluent standards: 0.1 mg/L; the following countries have set drinking water standards: Czechoslovakia (0.010 mg/L), EEC (5.0  $\mu\text{g/L}$ ), Japan (<0.01 mg/L); USSR/UNEP (0.01 mg/L); Kansas and Minnesota drinking water guideline: 5  $\mu\text{g/L}$ , Maine: 10  $\mu\text{g/L}$

**PROBABLE FATE: photolysis:** photolysis is not an important mechanism for determining fate of cadmium compounds; **oxidation:** in reducing condition, Cd may precipitate with reduced sulfur to form CdS; **hydrolysis:** aqueous solutions of cadmium salts are hydrolyzed to form volatile compounds; **volatilization:** it is known to form volatile compounds; **sorption:** sorption processes are important in determining cadmium transport, partitioning, and potential for remobilization; **biological processes:** accumulates in the tissues of aquatic and marine organisms at higher concentration; **other reactions/interactions:** organic ligands of biological origin may affect solubility and adsorption

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 69; *Gas flotation with chemical addition (calcium chloride, polymer)*, 79->98, 17; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, 36->99, 20; *Sedimentation*, 72->99, 210; *Sedimentation with chemical addition (lime, polymer)*, 27-93, <16; *Sedimentation with chemical addition ( $\text{Fe}^{2+}$ , lime)*, 25->50, 6; *Sedimentation with chemical addition (sulfide)*, >50->99, <9; *Sedimentation with chemical addition (polymer)*, 25-50, 80; *Sedimentation with chemical addition (alum, polymer)*, 42-61, 33; *Sedimentation with chemical addition (alum)*, 44-88, >9; *Sedimentation with chemical addition (lime)*, 60-99, >9; *Aerated lagoons*, >97, <2; *Ultrafiltration*, >83->93, <8.3; *Ozonation*, 0, negative removal; *Ion exchange*, >99, <10; *Activated sludge*, 31->99, 4; *Granular activated carbon adsorption*, 34-95, 12; *Reverse osmosis*, 13-50, 13

**KEY REFERENCES:** 14; 19; 21; 23; 27; 28

## CARBON TETRACHLORIDE ( $\text{CCl}_4$ , 153.8)

**CAS/DOT IDENTIFICATION #:** 56-23-5/UN 1846

**SYNONYMS:** tetrachloromethane, methane tetrachloride, perchloromethane, benzoinform; Carbon-chloride, Carbon-tet, Carbona, Flukoids, Freon-10, Halon-104, Methane, tetrachloro-, Necatorina, Perchloro-methane, R-10 (refrigerant), R-10, Teraform, Tetra-finol, Tetraform, Tetra-sol, Univerm, Vermoestricid

**PHYSICAL PROPERTIES:** colorless, clear, heavy liquid; sweetish, aromatic smell; insoluble in water; miscible with alcohol, ether, chloroform, benzene, solvent naphtha, and most fixed and nonvolatile oils; MP (-22.9°C); BP (76.5°C); SG (1.594); VS (1.329 cP @ 0°C); VP (90 torr @ 20°C); VD (5.32); solubility in water (800 mg/L @ 20°C); OT (>10 ppm); surface tension (liquid-water) (45 dynes/cm); surface tension (liquid) (270 dynes/cm); Log Kow (2.64);

H ( $30.2 \times 10^{-3}$  atm·m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** non-combustible; generally inert; HV (8271.5 g cal/g mol); HC (37.3 kg cal/g mol @ 20 °C); non-explosive; incompatible with alkali metals, finely powdered metals, and oxidizing agents

**BIOLOGICAL PROPERTIES:** ThOD: 0.21; Koc: 71; estimated retardation factor in breakthrough sampling in groundwater: 1.44-1.8; some released to atmosphere is expected to partition into the ocean; releases onto soil result in rapid evaporation due to its high vapor pressure and leaching in soil; low adsorption to soil, and highly mobile; very stable in troposphere, half-life: 30-50 yrs; aerobic half-life: 6 months-1 year; anaerobic half-life: 7-28 days; ground water half-life: 7 days-1 yr; soil and surface water half-life: 6 months-1 yr; non-persistent in water, half-life <2 days; can be detected in water by EPA Method 601: gas chromatography, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** fish (*Salmo gairdneri*): log P<sub>oct</sub>: 2.64, Log BCF: 1.24; Log BCF (bluegill sunfish): 1.48; the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** recovery of tin; formulation of petrol additives; refrigerants and propellants for aerosol cans; metal degreasing; production of semiconductors; to reduce fire hazard; cleaning agent for machinery and electrical equipment; formerly a dry-cleaning agent, a fire extinguisher, a pesticide; rubber cement; cable and semiconductor manufacture; oils; fats; lacquers; varnishes; rubber waxes; resins; nylon-7; organic chlorination processes; polymer technology; as reaction medium; catalyst; chlorination of organic compounds; soap perfumery; insecticides; starting material in manufacture of organic compounds; fluorocarbons; pesticides; hexachloroethane; tetrabromomethane; pyrosulfuryl chloride

**TOXICITY:** Toxicity threshold (cell multiplication test): bacteria (*Pseudomonas putida*): 30 mg/L, green algae (*Scenedesmus quadricauda*): >600 mg/L, protozoa (*Entosiphon sulcatum*): 770 mg/L; protozoa (*Uronema parducci Chatton-L-woff*): 616 mg/L; guppy (*Poecilia reticulata*): 14 d LC50: 67 ppm

**EXPOSURE ROUTES:** air from accidental release from production and uses; air from disposal in landfills; building materials; cleaning agents; manufacture of carbon tetrachloride; drinking contaminated water; ingestion of bread or other products made with carbon-tetrachloride-fumigated grain (in past); inhalation of vapor; percutaneous adsorption; ingestion and skin and eye contact

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life: 35,200 µg/L based on acute toxicity; Criterion to protect saltwater aquatic life: 50,000 µg/L based on acute toxicity; Criterion to protect human health: preferably 0; MCGL: 0; MCL: 0.005 mg/L; HAL: 1 day: 4 mg/L, 10 day: 0.2 mg/L; concentration calculated to keep the lifetime cancer risk level to 1 in 100,000: 4.0 µg/L; USSR/UNEP MAC: 0.3 mg/L; lifetime health advisory by EPA: 0.0007 mg/kg/day, and a drinking water equivalent of 25 µg/L; the following are guidelines in drinking water set by some states: 2 µg/L (New Jersey), 3 µg/L (Florida); 10 µg/L (New Mexico) 2.7 µg/L (Minnesota), 5 µg/L (California, Kansas, and Maine)

**PROBABLE FATE:** *photolysis*: could be important in aqueous environment, in the stratosphere, photodissociation occurs to eventually form phosgene as the principal product; *oxidation*: no information available, in troposphere it exhibits an extremely slow rate of reaction with hydroxyl radicals, photooxidation half-life in air: 1.8-18.3 yrs; *hydrolysis*: first-order hydrolytic half-life: 7000 yrs based on a rate constant of  $4.8 \times 10^{-7}$  mol<sup>-1</sup>s<sup>-1</sup> @ pH 7 and 25°C; *vola-*

**tilization:** volatilization is rapid and is an important transport process, measured half-life of evaporation from 1 ppm aqueous solution, still air and an avg. depth of 6.5 cm: 28.8 min, evaporation from water @ 25°C of 1 ppm solution: 50% after 29 min, 90% after 97 min; **sorption:** little data available, but adsorption onto sediments rich in organic material is possible; **biologic processes:** some bioaccumulation and biodegradation possible

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 1; *Gas flotation with chemical addition (calcium chloride, polymer)*, 50,1; *Gas flotation with chemical addition (alum, polymer)*, 76-410; *Filtration*, >73-93,<32; *Sedimentation with chemical addition (alum, lime)*, 25->50, 6; *Sedimentation with chemical addition (sulfide)*, >50->99, <9; *Sedimentation with chemical addition (polymer)*, >17, <10; *Sedimentation with chemical addition (alum, polymer)*, 94, 1800; *Activated sludge*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), ~100-50; *Powdered activated carbon adsorption* (based on synthetic wastewater), 98, 17; *Anaerobic continuous flow conditions*: 99% removal

**KEY REFERENCES:** 19; 21; 23; 25; 26; 27; 29; 30; 31

### CHLORDANE (C<sub>10</sub>H<sub>6</sub>Cl<sub>8</sub>, 409.8)

**CAS/DOT IDENTIFICATION #:** 57-74-9/UN 2762

**SYNONYMS:** 1,2,4,5,6,7,8-Octachloro-3a,,7,7a-tetrahydro-4,7-methanoindane

**PHYSICAL PROPERTIES:** colorless to amber-colored viscous liquid; pungent chlorine-like odor; MP (107-109°C); BP (175°C @ 2 torr); DN (1.6 g/cm<sup>3</sup> @ 25°C); SG (0.61 g/mL); VP (1x10<sup>-5</sup> torr @ 25°C); VD (3.9 g/cm<sup>3</sup> @ 20°C); solubility in water (1.85 mg/L @ 25°C); Log Kow (2.78); H (4.8x10<sup>-5</sup> atm-m<sup>3</sup>/mol); refractive index (5.75)

**CHEMICAL PROPERTIES:** stable; incompatible with reducing agents; will not polymerize; strong oxidizer and alkaline reagent; decomposes in weak alkalies; FP (10°F) LEL/UEL (1.1%, 6.7%)

**BIOLOGICAL PROPERTIES:** Koc: 15,500-24,600; very persistent in the adsorbed state in the aquatic environment; may persist in soil for long periods of time; mean degradation rate under field conditions: 4.05-28.33%/yr with a mean half-life of 3.3 yrs; generally immobile in soil, however movement to groundwater can occur; very slowly biotransformed in the environment; long range transport occurs; soil, surface water, and aerobic half-lives: 283 days-3.8 yrs; anaerobic half-life: 1-7 days; ground water half-life: 566-7.6 days; can be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** significant and important in aquatic organisms; BCF: generally >3,200; Log BCF (fish): 3.6-4.6; some evidence accumulation is reversible over time in the absence of further exposures; does not appear to be extensively concentrated in the higher membranes of the terrestrial food chain, i.e., homeotherms; the concentration found in fish tissues is expected to be considerably higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** pesticide; insecticide; household and veterinary uses; chlorination of chlordene; fumigant

**TOXICITY:** high acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** digging in soils in areas where it has been applied; occupational exposure in the manufacture and formulation; workers applying the chemical; eating contaminated food; inhalation; skin adsorption; ingestion; skin and eye contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.0043 µg/L/24 hr avg., not to exceed 2.4 µg/L any time; **Criterion to protect saltwater aquatic life:** 0.0040 µg/L/24 hr avg., not to exceed 0.09 µg/L any time; **Criterion to protect human health:** preferably 0; MCGL: 0 mg/L; MCL: 0.002 mg/L; HAL (child): 1 day and 10 day: 0.06 mg/L; concentration calculated to keep the lifetime cancer risk level to 1 in 100,000: 0.0046 µg/L; lifetime health advisory: 2 µg/L; the following are guidelines in drinking water set by some states: 0.5 µg/L (New Jersey), 3.0 µg/L (Illinois); 0.55 µg/L (California), 0.22 µg/L (Kansas and Minnesota), 0.5 µg/L (Arizona), 0.55 µg/L (Maine)

**PROBABLE FATE:** **photolysis:** sensitized process may be important, reacts in the vapor phase with photochemically produced hydroxyl radicals at an estimated half-life of 6.2 hr, suggesting that this reaction is the predominate chemical removal process; **oxidation:** photooxidation half-life in air: 5.2-51.7 hrs; **hydrolysis:** not an important process, first-order hydrolytic half-life: >197,000 yrs; **volatilization:** probably an important process, can volatilize significantly from soil surfaces from which it is sprayed, particularly moist soil surfaces, volatilization half-life from a model pond, river, and lake is: 18-26, 3.6-5.2, and 14.4-20.6 days respectively; **sorption:** probably an important process; **biological processes:** bioaccumulation is an important process

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 3; *Filtration*, 37,24; *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 0.5; physical removal via *wet and dry deposition* because of detection in rainwater

**KEY REFERENCES:** 19; 21; 23; 25; 26; 27; 29

## CHLOROBENZENE (C<sub>6</sub>H<sub>5</sub>Cl, 112.56)

**CAS/DOT IDENTIFICATION #:** 108-90-7/UN 1134

**SYNONYMS:** monochlorobenzene, benzene chloride; pherol chloride; chlorobenzol; mcb; monochlorobenzene; phenyl chloride

**PHYSICAL PROPERTIES:** clear, colorless liquid; almond-like odor; MP (-45°C); BP (132); DN (1.1058 g/mL @ 20°C); VS (0.79 cP @ 21.1°C); SG (1.11); VP (12 mmHg @ 25°C); VD (3.9); solubility in water (472 mg/L @ 25°C); OT (0.21 ppm); surface tension (33 dynes/cm @ 25°C); Log Kow (2.84); H (3.93x10<sup>-5</sup> atm·m<sup>3</sup>/mol)

**CHEMICAL PROPERTIES:** generally very stable; reacts with strong oxidizers; HC (6700 cal/g); FP (28°C); LEL/UEL (1.3%, 7.1%); AT (592°C);

**BIOLOGICAL PROPERTIES:** ThOD: 2.06; ring distribution by *Pseudomonas* at 200 mg/L: parent: 100% in 58 hr, mutant: 100% in 14 hr; once released, it will decrease in concentration due to dilution and photooxidation; release to water and soil will dissipate due to vaporization and slow biodegradation in the soil or water; rapid mineralization (20%/week) is reported;

acclimation of soil microcosms to hydrocarbon metabolism is an important factor; relatively mobile in sandy soil and aquifer material; expected to leach into groundwater; surface water, soil, and aerobic half-lives: 68-150 days; anaerobic half-life: 272-600 days; ground water half-life: 136-300 days; can be detected in water by EPA Methods 601 and 602: gas chromatography, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** little bioconcentration is expected into fish and food products; Log BCF (for several species of fish): 1-2

**ORIGIN/INDUSTRY SOURCES/USES:** dyestuffs; manufacture of phenols, aniline, cumene, DDT, chloronitrobenzenes, o- and p- dichlorobenzene; insecticides; adhesives; paints; polishes; waxes; pharmaceuticals; textiles; dry cleaning; surface coatings; tar and grease remover; surface coating removers; natural rubbers; heat transfer medium

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 17 mg/L, algae (*Microcystis aeruginosa*): 120 mg/L, green algae (*Scenedesmus quadricauda*): >390 mg/L, protozoa (*Entosiphon sulcatum*): >390 mg/L; protozoa (*Uronema parduczi Chatton-L-woff*): >392 mg/L; fatheads: 24-96 hr, TLm: 29-39 mg/L; bluegills: 24-96 hr, TLm: 24 mg/L; goldfish: 24-96 hr, TLm: 51-73 mg/L; guppies: 24-96 hr, TLm: 45 mg/L; rainbow trout; 24 hr LC50: 1.8 mL/kg; guppy (*Poecilia reticulata*): 14 d LC50: 19 ppm

**EXPOSURE ROUTES:** fugitive emissions from use as a solvent; inhalation; ingestion; eye contact; skin contact; occupational exposure; contaminated drinking water; intraperitoneal route

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 250 µg/L based on acute toxicity for chlorobenzenes as a class; **Criterion to protect saltwater aquatic life:** 160 µg/L based on acute toxicity, 120 µg/L based on chronic toxicity; **Criterion to protect human health:** for then prevention of adverse toxicological effects: 488 µg/L, to prevent adverse organoleptic effects: 20 µg/L; USSR/UNEP MAC in water bodies used for domestic purposes: 0.02 µg/L; MCGL: 0.1 mg/L; MCL: 0.1 mg/L; HAL: 1 to 10 day: 2 mg/L, longer term: 2 mg/L; lifetime health advisory set by EPA: 0.3 mg/L; the following are guidelines in drinking water set by some states: 2 µg/L (New Jersey), 30 µg/L (California), 47 µg/L (Maine), 60 µg/L (Arizona, Kansas, and Minnesota), 600 µg/L (Vermont and Wisconsin)

**PROBABLE FATE:** **photolysis:** probably occurs slowly; **oxidation:** no data on aqueous oxidation, photooxidation of volatilized chlorobenzene is slower than photooxidation of benzene, photooxidation half-life in water: 64.7 days-7.1 yrs; photooxidation half-life in air: 3.0-30.4 days; **hydrolysis:** not an important process, first-order hydrolytic half-life: >879 yrs; **volatilization:** very rapid volatilization is the main transport process, in water, the primary loss is due to evaporation, half-life estimated at 10-11 hrs, half-life for evaporation with moderate speed: 4.5 hrs; **sorption:** presumably sorbed by organic materials, moderate adsorption onto organic soil; **biological processes:** high potential for bioaccumulation and magnification, biodegradation is very slow, and will occur during warmer seasons and will produce more rapidly in fresh water than in estuarine and marine systems; **other reactions/interactions:** low probability of further chlorinating chlorobenzene with reaction with chlorine containing water

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L) *Filtration*, 0, negative removal; *Activated sludge*, 71->99, 5; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Granular activated carbon adsorption*, >96, <0.2; *Powdered activated carbon adsorption* (based on synthetic wastewater), 95, 1400

**KEY REFERENCES:** 19; 21; 23; 25; 26; 31

**CHLORODIBROMOMETHANE (CHBr<sub>2</sub>Cl, 208.3)****CAS/DOT IDENTIFICATION #:** 124-48-1/UN not available**SYNONYMS:** dibromochloromethane, CDBM**PHYSICAL PROPERTIES:** clear, colorless liquid; MP (<-20°C); BP (119-120°C); DN (2.451 @ 20°C); SG (2.38); VP (15 torr @ 10.5°C); water solubility (4400 ppm @ 22°C); Log Kow (2.09); H (0.783x10<sup>-3</sup> atm·m<sup>3</sup>/mole); refractive index (1.5482 @ 20°C)**CHEMICAL PROPERTIES:** probably combustible; incompatible with strong bases, strong oxidizing agents, and magnesium; FP (>93°C)**BIOLOGICAL PROPERTIES:** moderately to highly mobile in soil; expected to leach into groundwater; long range global transport is possible; aerobic continuous flow degradation: 99% degraded; 25-39% loss using a static flask screening procedure and 28 days of incubation; relative resistance to biodegradation under aerobic conditions; aerobic tests using mixed methanogenic bacterial cultures from sewage effluents: total degradation within 2 weeks and 43-50% lost in sterile controls after 6 weeks; no degradation in aerobic tests under sterile or seeded conditions; anoxic conditions with denitrifying bacteria: 50% degradation in bacterial cultures after 8 weeks, no degradation in sterile controls; soil, surface water, aerobic, and anaerobic half-lives: 4 weeks-6 months; ground water half-life: 14 days-6 months;**BIOACCUMULATION:** BCF (estimated from regression equations based on water solubility and log Kow): 0.74-1.47; there is a potential for accumulation in the aquatic environment because of its resistance to degradation**ORIGIN/INDUSTRY SOURCES/USES:** formed from the haloformation reaction that may occur during water chlorination; lab chemical; organic synthesis; chemical intermediate in the manufacture of fire extinguishing agents, aerosol propellants, refrigerants and pesticides**TOXICITY:** not available**EXPOSURE ROUTES:** drinking water; consumption of beverages and food products; inhalation of contaminated ambient air; dermal exposure to chlorinated swimming pool water**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** MCL: 0.1 mg/L; Illinois guideline in drinking water: 1.0 µg/L**PROBABLE FATE:** **photolysis:** could be important, only identifiable transformation process if released to air is reaction with hydroxyl radicals with an estimated half-life of 8.4 months; **oxidation:** has a possibility of occurring, photooxidation half-life in air: 42.7 days-1.2 yrs; **hydrolysis:** too slow to be important, first-order hydrolytic half-life: 275 yrs; **volatilization:** likely to be a significant transport process, if released to water or soil, volatilization will be the dominant environmental fate process, volatilization half-life from rivers and streams: 43 min-16.6 days with a typical half-life being 46 hrs; **sorption:** adsorption onto activated carbon has been demonstrated; **biological processes:** moderate potential for bioaccumulation, biodegradation occurs in some organisms, in aquatic media where volatilization is not possible, anaerobic degradation may be the major removal process; **other reactions/interactions:** may be formed from haloform reaction after chlorination of water if sufficient bromide is present**TREATABILITY/REMOVABILITY (Process, Removable Range (%), Avg. Achievable Conc. (µg/L)):** *Sedimentation*, >77, <10; *Sedimentation with chemical addition*, >50, <0.3;

*Activated sludge* (based on synthetic wastewater), 39, 3050; *Activated carbon* has also been demonstrated as a removal process;

**KEY REFERENCES:** 11; 21; 23; 25; 26; 28; 30

### CHLOROETHANE (C<sub>2</sub>H<sub>5</sub>Cl, 64.52)

**CAS/DOT IDENTIFICATION #:** 75-00-3/UN 1037

**SYNONYMS:** aethylis, aethylis chloridium, anodynon, chelen, chloridum, ethyl chloride, chloroethyl, chloryl, chloryl anesthetic, ether chloratus, ether hydrochloric, ether muriatic, hydrochloric ether, kelene, monochloroethane, muriatic ether

**PHYSICAL PROPERTIES:** colorless liquid; gas at ordinary temperatures; ether-like odor; slightly soluble in water; miscible in alcohol and ether; burns with a smoky green flame; floats and may boil on water; MP (-138.7°C); BP (12.5°C); DN (0.9214 g/mL); SG (0.891); VP (1000 mmHg @ 20°C); VD (2.22); OT (4.2 ppm); solubility in water (5,740 mg/L @ 20°C); Log Kow (1.54); Log Poct (1.54); refractive index (1.3676 @ 20°C)

**CHEMICAL PROPERTIES:** volatile at room temperature; reacts with strong oxidizing agents, sodium, potassium, and their alloys; forms highly flammable mixtures with air; FP (-50°C); AT (518°C); LFL/UFL (3.6%, 14.8%)

**BIOLOGICAL PROPERTIES:** Koc (estimated values): 33 and 143; non-persistent in water; highly mobile in soil and expected to leach significantly into groundwater; half-life in water is less than 2 days; soil, surface water and aerobic half-lives: 7 days-4 weeks; ground water half-life: 14 days-8 weeks; anaerobic half-life: 28 days-16 weeks

**BIOACCUMULATION:** the concentration found in fish tissues is expected to be about the same as the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of tetraethyl lead and ethylcellulose; solvent for phosphorus, fats, resins, sulfur, oils, and waxes; anesthetic; alkylating agent; analytical reagent; organic synthesis; refrigeration

**TOXICITY:** slight acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** primarily through inhalation; adsorption through skin; process and fugitive emissions; evaporation; stack emissions from plastics and refuse combustion; leaching from landfills; contaminated ambient air, and drinking water; dermal exposure through use of topical anesthetic cooling agent

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** no criteria set due to volatility and low specific gravity; **Criterion to protect saltwater aquatic life:** no criteria set due to volatility and low specific gravity; **Criterion to protect human health:** no criteria set due to volatility and low specific gravity

**PROBABLE FATE:** **photolysis:** no information available pertaining to the rate of photodissociation in aqueous environment, photodissociation to formyl chloride may occur in stratosphere, predominate fate process, if released to the atmosphere, is the reaction with photochemically produced hydroxyl radicals with an estimated half-life of 40 days, less than 1% will eventually diffuse above the ozone layer where it will be destroyed by photolysis, direct photolysis is not important; **oxidation:** photooxidation in troposphere is the primary fate mechanism, photo-

oxidation in the aquatic environment probably occurs at a slow rate, photooxidation half-life in air: 6.67-66.8 days; **hydrolysis**: hydrolyzes in the presence of water or alkalies, not expected to compete with volatilization, first-order hydrolytic half-life: 38 days @ 25°C, in groundwater, hydrolysis may be the primary removal mechanism since volatilization may not be able to occur; **volatilization**: probably the primary transport mechanism, evaporation from water @ 25°C of 1 ppm solution (still air, avg. depth of 6.5 cm): 50% after 21 min, 90% after 79 min, volatilization half-lives in water range from 1.1-5.6 days, if released to soil, will evaporate rapidly where release to air is possible; **sorption**: no data is available, not expected to be important; **biological processes**: no data is available, biodegradation and bioaccumulation are not expected to be important fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Granular activated carbon adsorption*, 58->99, 71000; *Powdered activated carbon adsorption* (based on synthetic wastewater), 88, 129

**KEY REFERENCES**: 19; 21; 23; 25; 26; 27; 28; 30

## 2-CHLOROETHYLVINYLETHER (C<sub>4</sub>H<sub>7</sub>ClO, 106.6)

**CAS/DOT IDENTIFICATION #**: 110-75-8/ UN 1993

**SYNONYMS**: vinyl 2-chloroethyl ether, (2-chloroethoxy) ethene, 2'-chloroethyl ethenyl ether, 2-chloroethylvinylether, 2-chloroethylvinyl ether, 2-Vinyloxyethyl chloride

**PHYSICAL PROPERTIES**: colorless liquid; slightly soluble in water; very soluble in alcohol and ether; MP (-69.7°C); BP (109°C); DN (1.0495 @ 20°C); SG (1.0475); VP (26.75 mmHg @ 20°C); solubility in water (6,000 mg/L @ 20°C); Log Kow (1.28); H (6.25x10<sup>-4</sup> atm·m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES**: incompatible with oxidizing materials; highly flammable; FP (27°C)

**BIOLOGICAL PROPERTIES**: Koc: 22-118; expected to leach if released to soil; biodegradation in soil possible; can be detected in water by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION**: BCF: 3-5; not expected to bioaccumulate in aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES**: synthetic organic chemical; manufacture of anesthetics, sedatives, cellulose ethers; copolymer of 95% ethyl acrylate with 5% 2-chloroethyl vinyl ether has been used to produce acrylic elastomer; no longer produced in the USA

**TOXICITY**: not available

**EXPOSURE ROUTES**: workers involved with fabricated metal products, wholesale trade, leather, rubber, plastic, chemical products

**REGULATORY STATUS**: **Criterion to protect freshwater aquatic life**: criterion has not been developed; **Criterion to protect saltwater aquatic life**: criterion has not been developed; **Criterion to protect human health**: criterion has not been developed

**PROBABLE FATE:** *photolysis:* direct photolysis is not expected to be important, half-life for reaction with photochemically produced hydroxyl radicals in air: 12 hrs; *oxidation:* atmospheric photooxidation after volatilization is the principal fate; *hydrolysis:* if compound is adsorbed by clays or fulvic acids, hydrolysis is not very important, important in acidic soils or soils processing acidic sites, if released to water, slow hydrolysis at neutral pH with a half-life of 50 yrs, at pH of 5, hydrolysis half-life: 6.9 days; *volatilization:* high vapor pressure indicates strong volatilization, volatilization from the soil surfaces to the atmosphere and from water is an important fate process, volatilization half-life from a model river and pond: 4.4hrs and 52 hrs respectively; *sorption:* expected to be adsorbed by clays and humic materials; *biological processes:* insufficient data; *reaction with ozone:* half-life: 1.3 days; rain wash-out should also be considered a likely fate process

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption* (based on synthetic wastewater), 93, 2300

**KEY REFERENCES:** 21; 22; 23; 28; 30

### CHLOROFORM ( $\text{CHCl}_3$ , 119.38)

**CAS/DOT IDENTIFICATION #:** 67-66-3/UN 1888

**SYNONYMS:** chloroforme, chloroformio, formyl trichloride, freon-20, methane trichloride, methenyl chloride, methenyl trichloride, methyl trichloride, trichloroform, trichloromethane

**PHYSICAL PROPERTIES:** clear, colorless liquid; pleasant, sweet odor; slightly soluble in water; MP ( $-63^\circ\text{C}$ ); BP ( $62^\circ\text{C}$ ); DN ( $1.4832 \text{ g/cm}^3 @ 20^\circ\text{C}$ ); SG (1.48); surface tension ( $27.1 \text{ dynes/cm} @ 20^\circ\text{C}$ ); VS ( $5.63 \text{ mP} @ 20^\circ\text{C}$ ); VP ( $100 \text{ mmHg} @ 10.4^\circ\text{C}$ ); VD (4.13); solubility in water ( $9,600 \text{ mg/L} @ 20^\circ\text{C}$ ); OT ( $3.30 \text{ mg/L}$ ); HV ( $59.3 \text{ cal/g}$ ); Log Kow (1.97); H ( $3.39 \times 10^{-3} \text{ atm}\cdot\text{m}^3/\text{mole}$ )

**CHEMICAL PROPERTIES:** generally stable; nonflammable; addition to acetone in the presence of a base will result in a highly exothermic reaction; reacts vigorously with disilane when exposed to sunlight; decomposes to form hydrochloric acid, phosgene, and chlorine upon contact with a flame

**BIOLOGICAL PROPERTIES:** ThOD: 1.346 and 0.33; spills and releases on land expected to leach into groundwater and will reside for long periods of time, photodegradation half-life is within a few months; majority of the releases are to the atmosphere; soil, surface water and aerobic half-lives: 4 weeks-6 months; ground water half-life: 8 weeks-5 years; anaerobic half-life: 1-4 weeks; can be detected in water by EPA Method 601: gas chromatography, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** not expected to bioconcentrate into the food chain; the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** general anesthetic (former use); component of cough syrups, toothpastes (former use), toothache compound (former use), liniments; general solvent for adhesives, pesticides, fats, oils, rubbers, alkaloids, waxes, gutta-percha, resins, penicillins; cleansing agent; rubber industry; in fire extinguishers to lower the freezing temp. of car-

bon tetrachloride; insecticidal fumigant; chemical intermediate; dry cleaning agent; polymer chain transfer agent.

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 125 mg/L, algae (*Microcystis aeruginosa*): 185 mg/L, green algae (*Scenedesmus quadricauda*): 1100 mg/L, protozoa (*Entosiphon sulcatum*): >6560 mg/L; protozoa (*Uronema parducazi Chatton-L-woff*): >6560 mg/L

**EXPOSURE ROUTES:** inhalation; ingestion; eye contact; skin contact and adsorption; drinking contaminated water; occupational exposure; automobile exhaust; atmospheric decomposition of trichloroethylene

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** 28,900 µg/L based on acute toxicity, 1240 based on chronic toxicity; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 1.9 µg/L; USSR limit in surface water: 0.06 mg/L; the following are guidelines in drinking water set by some states: 1.0 µg/L (Illinois); 3.0 µg/L (Arizona), 5 µg/L (Minnesota)

**PROBABLE FATE: photolysis:** could be important, photodissociation can occur in stratosphere, photooxidation half-life in water: 78.5-3140 yrs, photooxidation half-life in air: 26-260 days; **oxidation:** could be important in sunlight, in troposphere oxidation by hydroxyl radicals to phosgene and chlorine oxide is important fate mechanism, half-life: 80 days; **hydrolysis:** not an important fate process, first-order hydrolytic half-life: 3500 yrs; **volatilization:** volatilization is a major transport process for removal from aqueous mediums, volatilization half-lives from a river, pond and lake are: 36 hrs, 40 hrs, and 9-10 days respectively, evaporation half-life from 1 ppm aqueous solution (still air, avg. depth of 6.5 cm): 34.5 min @ 1-2°C, 18.5-25.7 min @ 25°C, evaporation from water @ 25°C of 1 ppm solution: 50% after 18-25 min, 90% after 62-83 min; **sorption:** data is lacking, sorption by inorganic and organic materials not expected to be an important fate; **biological processes:** data is lacking, some bioaccumulation is indicated and biodegradation may be possible

**TREATABILITY/REMOVABILITY (Process, Removable Range (%), Avg. Achievable Conc. (µg/L)):** *Gravity oil separation*, not available, 58; *Gas flotation*, 0, negative removal; *Gas flotation with chemical addition (calcium chloride, polymer)*, 31-74, 5.9; *Gas flotation with chemical addition (polymer)*, 41,24; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, 0, negative removal; *Sedimentation*, 16->81, 110; *Sedimentation with chemical addition (alum, lime)*, 0, negative removal; *Sedimentation with chemical addition (lime, polymer)*, 26->78, <9; *Sedimentation with chemical addition (polymer)*, 0, negative removal; *Sedimentation with chemical addition (alum, polymer)*, 27->94, 140; *Sedimentation with chemical addition (alum)*, 0, negative removal; *Aerated lagoons*, 36->57, 340; *Steam stripping*, 89->99, 13000; *Trickling filters*, 0, negative removal; *Activated sludge*, 63->99, <13; *Granular activated carbon adsorption*, >67->99, <11; *Powdered activated carbon adsorption* (based on synthetic wastewater), 97, 30; *Reverse osmosis*, 20-79, 16

**KEY REFERENCES:** 19; 21; 23; 25; 26; 27; 30

## CHLOROMETHANE (CH<sub>3</sub>Cl, 50.59)

**CAS/DOT IDENTIFICATION #:** 74-87-3/UN 1063

**SYNONYMS:** arctic, methyl chloride, monochloromethane

**PHYSICAL PROPERTIES:** colorless compressed gas or liquid; faintly sweet; ethereal odor; slightly soluble in water; very soluble in ethyl alcohol; MP (-97.7°C); BP (-24.4°C); DN (0.918 g/mL); SG (0.915); VP (3796 mmHg @ 20°C); VD (1.74 g/m<sup>3</sup>); solubility in water (6,450-7,250 mg/L @ 20°C); OT (100 ppm); Log Kow (0.91)

**CHEMICAL PROPERTIES:** attacks aluminum, magnesium, and zinc; incompatible with chemically active metals; FP (<32°C); AT (631°C); LEL/UEL (7%, 19%)

**BIOLOGICAL PROPERTIES:** non-persistent in water, with a half-life of <2 days; potential to leach into groundwater, even though it will be rapidly lost by volatilization if released onto soil; may very slowly biodegrade and hydrolyze from soil, with a half-life greater than 1 yr; will disperse in atmosphere once released and will be lost primarily by upward dispersion; surface half-life resulting from upward diffusion; 81 days; soil, surface water and aerobic half-lives: 7 days-4 weeks; ground water half-life: 14 days-8 weeks; anaerobic half-life: 28 days-16 weeks; can be detected in water by EPA Method 601: gas chromatography, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** the concentration found in fish tissues is expected to be about the same as the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** formed in ocean; protective colloid in water-based paints to prevent flocculation of pigment; production of silicones; agricultural chemicals; methyl cellulose; butyl rubber; film and sheeting; binder in ceramic glazers; leather tanning; dispersing agent; thickening agent; sizing agent; herbicide; fumigant; adhesive; food additive; refrigerant; lab reagent; local anesthetic; catalyst carrier in lower temperatures

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 500 mg/L, algae (*Microcystis aeruginosa*): 550 mg/L, green algae (*Scenedesmus quadricauda*): 1450 mg/L, protozoa (*Entosiphon sulcatum*): 8000 mg/L

**EXPOSURE ROUTES:** home burning of wood, coal, and certain plastics; chlorinated swimming pools; drinking water at low levels; cigarette smoke; polystyrene insulation; aerosol propellants; forest and brush fire; volcanoes; adsorption through skin and lungs; occupational exposure: car dealers, metal industries, building contractors

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 7000 µg/L/24 hr avg., concentration not to exceed 320 µg/L any time; **Criterion to protect saltwater aquatic life:** 3700 µg/L/24 hr avg., concentration not to exceed 8400 µg/L any time; **Criterion to protect human health:** 2 µg/L, preferably 0; lifetime cancer risk of 1 in 100,000: 1.9 µg/L; the following are guidelines in drinking water set by some states: 0.19 µg/L (Kansas); 0.50 µg/L (Arizona)

**PROBABLE FATE:** **photolysis:** information is lacking, probably unimportant, appreciable photodissociation may occur in stratosphere, photooxidation half-life in air: 61.3-613 days; **oxidation:** information lacking, probably unimportant, in troposphere oxidation by hydroxyl radicals for formyl chloride and other products is an important fate; **hydrolysis:** slow hydrolysis, unimportant in comparison to volatilization, first-order hydrolytic half-life: 292 days at pH 7; **volatilization:** volatilization to the atmosphere is rapid and is a major transport process for removal of methyl chloride, evaporation from water @ 25°C of 1 ppm solution: 50% after 27 min, 90% after 91 min; volatilization half-life in a typical river: 2-1 hr; **sorption:** no data is available, sorption onto sediments and suspended particulates probably unimportant; **biological processes:** data is lacking, biodegradation and bioaccumulation are not expected to be important fates

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Filtration*, >87, <0.4; *Sedimentation*, 59->99, 64; *Aerated lagoons*, >91, <5; *Reverse osmosis*, 0, negative removal

**KEY REFERENCES:** 19; 21; 23; 24; 25; 26; 27; 30

## 2-CHLORONAPHTHALENE ( $\text{C}_{10}\text{H}_7\text{Cl}$ , 162.6)

**CAS/DOT IDENTIFICATION #:** 91-58-7

**SYNONYMS:** halowax, B-chloronaphthalene, 2-Chlornaftalen

**PHYSICAL PROPERTIES:** soluble in benzene, chloroform, carbon dioxide, and ether; MP (61°C); BP (256°C); DN (1.2656 g/mL @ 16°C); SG (1.2656); VP (0.017 torr @ 20°C); solubility in water (6.74 mg/L @ 25°C); Log Kow (4.12); H (3.15x10<sup>-4</sup> atm·m<sup>3</sup>/mole @ 25°C); refractive index (1.6079 @ 13°C)

**CHEMICAL PROPERTIES:** chemical and dermal stability; may react with strong oxidizers; volatile with steam

**BIOLOGICAL PROPERTIES:** Koc (using regression equations): 1130; low mobility in soil; expected to biodegrade slowly; aerobic biodegradation half-life: 59-79 days; chlorinated naphthalenes are more resistant to biodegradation than naphthalene; the higher the degree of chlorination, the more slowly a particular chloronaphthalene will be degraded; can be detected in water by EPA Method 612: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** expected to bioconcentrate in aquatic organisms; Log BCF (tissue of 1 yr old female guppies (*Poecillia reticulata*)): 3.63 after 7 days exposure to water concentrations between 100-750  $\mu\text{g/L}$

**ORIGIN/INDUSTRY SOURCES/USES:** oil additive; electroplating industry; fabric dyeing; production of electric condensers; insulation of electric cables and wires; supports for storage batteries; solvent; immersion liquid in microscopy

**TOXICITY:** aquatic toxicity is not available

**EXPOSURE ROUTES:** inhalation of fumes; percutaneous adsorption of liquid; ingestion of contaminated drinking water; skin contact; eye contact; effluents at sites where it is produced or used with other monochloronaphthalenes; cooling water discharges; leachates from hazardous waste sites; effluents from gaseous diffusion facilities and municipal waste incinerators; pyrolysis of vinylidene chloride polymer

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 1,600  $\mu\text{g/L}$  based on acute toxicity; **Criterion to protect saltwater aquatic life:** 7.5  $\mu\text{g/L}$  based on acute toxicity; **Criterion to protect human health:** insufficient data

**PROBABLE FATE:** *photolysis:* some of the dissolved compound may be photolyzed slowly, able to undergo direct photolysis in sunlight media, reaction with photochemically produced hydroxyl radicals has a half-life of 23 hr and a rate constant of 1.65x10<sup>-11</sup> cm<sup>3</sup>/molecule-sec @ 25°C; *oxidation:* probably too slow to be an important process; *hydrolysis:* not an im-

portant process, the neutral rate constant for hydrolysis in water is  $9.5 \times 10^{-6}$  @ 25°C, half-life: 8.3 yrs; **volatilization**: slow volatilization has been recorded; volatilization half-life from a model river and a model pond (considering adsorption): 7 hrs and 16 days respectively, may evaporate from dry surfaces; **sorption**: expected to be adsorbed onto particulates, especially organic matter; **biological processes**: short-term bioaccumulation expected to occur; biodegradation and metabolization are both reasonably rapid

**TREATABILITY/REMOVABILITY** (Process, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gas flotation with chemical addition (alum, polymer)*, 3, 16; *Filtration*, 0, negative removal; *Sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Aerated lagoons*, >47, <10; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 20; can be removed from the atmosphere by wet deposition

**KEY REFERENCES**: 21; 23; 24; 28; 30

## 2-CHLOROPHENOL (C<sub>6</sub>H<sub>5</sub>ClO, 128.56)

**CAS/DOT IDENTIFICATION #**: 95-57-8/ UN 2020 (solid)

**SYNONYMS**: 1-chloro-2-hydroxybenzene, o-chlorophenol

**PHYSICAL PROPERTIES**: colorless liquid; faint odor; MP (7°C); BP (175.6°C); SG (1.241); VP (40 mm @ 82°C); OT (0.00018 mg/L); solubility in water (28,500 mg/L @ 20°C); Log Kow (2.17); H ( $5.6 \times 10^{-7}$  atm-m<sup>3</sup>/mole); pKa (8.52); Log Poct (2.15-2.19)

**CHEMICAL PROPERTIES**: incompatible with oxidizing agents; FP (64°C)

**BIOLOGICAL PROPERTIES**: 96% removal @ 20°C in activated sludge at a rate of 25 mg COD/g dry inoculum/hr; decomposition rate in soil suspensions: 14 days for complete disappearance; decomposition period for a soil microflora: >64 days; inhibition of degradation of glucose by *Pseudomonas fluorescens*: 30 mg/L; inhibition of degradation of glucose by *E.coli*: 400 mg/L; degradation by *Pseudomonas*: 100% ring distribution at 30 °C of a 200 mg/L solution in 52 hr, mutant: 100% ring disruption in 26 hr; low to moderate adsorption to soil; may leach to ground water; can be detected in water by EPA Method 604: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION**: BCF (in fish @ 20 ppm): 6.4; BCF (bluegill sunfish): 214; BCF (goldfish): 7.1; BCF (estimated from water solubility and Log Kow): 1.9 and 25 respectively; not expected to bioconcentrate in aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES**: organic synthesis; manufacture of fungicides, slimicides, bactericides, pesticides, herbicides, disinfectants, wood and glue preservatives; in production of phenolic resins; extraction of minerals from coal; denaturant for ethanol; antiseptic; disinfectant

**TOXICITY**: concentration causing adverse taste in fish: 0.015 mg/L; algae (*Chlorella pyrenoidosa*, *Scenedesmus*): toxic: 96 mg/L, 60 mg/L; bacteria (*Pseudomonas*): toxic: 30 mg/L; protozoa (*Colpoda*): toxic: 30 mg/L; Fish: bluegill fingerlings: 96 hr TLM: 8.4 mg/L, bluegill sunfish: 24 hr TLM: 8.2 mg/L, fatheads: 24-96 hr TLM: 22-11 mg/L, bluegills: 24-96 hr TLM: 12-8 mg/L, goldfish: 24-96 hr TLM: 15-12 mg/L, guppies: 24-96 hr TLM 23-20 mg/L, goldfish:

24 hr LC<sub>50</sub>: 16 ppm; amount found dead in fish @ 20 ppm: 128 µg/g; guppy (*Poecilia reticulata*): 24 hr LC<sub>50</sub>: 11 ppm @ pH 7.3

**EXPOSURE ROUTES:** contaminated drinking water; handling and inhalation by industrial workers; dermal exposure is negligible

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** 4,380 µg/L based on acute toxicity, 60 µg/L/24 hr avg., concentration not to exceed 180 µg/L any time; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** 0.1 µg/L for the prevention of adverse effects due to organoleptic properties; the guideline in drinking water set by Kansas is 0.1 µg/L

**PROBABLE FATE: photolysis:** occurs in aqueous alkali, photolysis may occur near surface of waters and in atmosphere; **oxidation:** probably cannot compete with biodegradation, complete oxidation by *Pseudomonas* isolated from activated sludge; **hydrolysis:** not an important process; **volatilization:** too slow to be important, evaporation half-life: 73 days; **sorption:** slight potential for adsorption by lipophilic materials, may adsorb to sediments if released in water; **biological processes:** no bioaccumulation; more resistant to biodegradation than phenol, complete removal by biodegradation in 13-36 days in river waters; **other reactions/interactions:** chlorination of water could further chlorinate the compound

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 33; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Sedimentation*, 44->88, <10; *Sedimentation with chemical addition (lime, polymer)*, 0, <5; *Activated sludge*, 46-92, 5.5; *Powdered activated carbon adsorption*, 81, 190000

**KEY REFERENCES:** 21; 22; 23; 24; 25

#### 4-CHLOROPHENYL-PHENYLETHER (C<sub>12</sub>H<sub>9</sub>ClO, 203.7)

**CAS/DOT IDENTIFICATION #:** 7005-72-3/UN not available

**SYNONYMS:** 1-chloro-4-penoxybenzene; p-chlorophenyl phenyl ether, 4-dichlorodiphenyl ether, 4-chlorophenyl ether, p-chlorodiphenyl oxide

**PHYSICAL PROPERTIES:** liquid; MP (-8°C); BP (284°C); DN (1.2026 @ 15°C); VP (0.0027 torr @ 25°C); solubility in water (3.3 mg/L @ 25°C); Log Kow (4.08); H (8.4x10<sup>-4</sup> atm·m<sup>3</sup>/mole); refractive index (1.599)

**CHEMICAL PROPERTIES:** combustible; very unstable

**BIOLOGICAL PROPERTIES:** Koc: 2,260-3,950; slight mobility in soil; absorption greater than 290 nm; can be detected in water by EPA Method 611: methylene chloride extraction followed by gas chromatography with halide-specific detector, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** should bioaccumulate in aquatic organisms; BCF (rainbow trout by experiment): 736

**ORIGIN/INDUSTRY SOURCES/USES:** dielectric fluid

**TOXICITY:** not available

**EXPOSURE ROUTES:** released to environment through its manufacture, formulation, and use in capacitors; inhalation; dermal contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** insufficient data.

**PROBABLE FATE:** *photolysis:* could be important is adsorbed by sensitizer-containing humus, direct photolysis in surface water half-life: 200-400 days, direct photolysis in air is expected to be an important fate process, possible reaction with photochemically produced hydroxyl radicals with a half-life of 1.3 days; *oxidation:* not an important process; *hydrolysis:* not an important process; *volatilization:* expected to be important, volatilization from water should be an active fate process, volatilization for a model river half-life: 6 hours, from a model pond taking into account adsorption processes, half-life: 40 days; *sorption:* adsorption by humus, possible adsorption by clays, expected to adsorb to sediments and suspended material if released to water, sediment to water distribution ratio: 4:1 for 4-chlorophenyl phenyl ether during biodegradation studies with sludge; *biological processes:* possible bioaccumulation; gradual biodegradation: 1.5-4 hrs in activated sewage sludge, expected to undergo biodegradation in soil and in water

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Activated sludge* (based on synthetic wastewater), 36, 3200; *Powdered activated carbon adsorption* (based on synthetic wastewater), 98, 260

**KEY REFERENCES:** 4; 23; 28; 30

## CHROMIUM (Cr, 52.00)

**CAS/DOT IDENTIFICATION #:** 7440-47-3/UN not available

**SYNONYMS:** Chrome

**PHYSICAL PROPERTIES:** steel, gray metallic pieces, powder, and flakes; odorless; chromium (III) compounds are sparingly soluble in water; chromium (IV) compounds are readily soluble in water; MP (1890°C); BP (2672°C); DN (7.14 g/cm<sup>3</sup>); SG (7.14); VP (1 mmHg @ 1616°C); VD (7.1 g/cm<sup>3</sup>); solubility (6.17x10<sup>-5</sup> mg/L @ 0°C CrO<sub>3</sub> (as H<sub>2</sub>CrO<sub>4</sub>)); HV (81.7 kcal/g-atom)

**CHEMICAL PROPERTIES:** reacts with dilute HCl and H<sub>2</sub>SO<sub>4</sub>; attacked by caustic alkalis and alkali carbonates; not oxidized by air, even in presence of much moisture

**BIOLOGICAL PROPERTIES:** not likely to migrate to groundwater; uptake by plants is generally low; chromium compounds are very persistent in water, half-life >200 days; most in surface waters may be present in particulate form as sediment; Cr (IV) is the major stable form in seawater; can be detected in water by digestion followed by atomic absorption or by colorimetry analysis or by Inductively Coupled Plasma Optical Emission Spectrometry; chromium (IV) can be detected by extraction and atomic adsorption or colorimetry; dissolved forms can be detected by 0.45 $\mu$  filtration followed by the previous methods

**BIOACCUMULATION:** high potential for bioconcentration in aquatic organisms, although little data is available; BCF (snails):  $1 \times 10^6$ ; BCF (plants): 1000

**ORIGIN/INDUSTRY SOURCES/USES:** making steel; alloys; bricks in furnaces; increases resistance and durability of metals; protective coating for automotive and equipment accessories; nuclear and high temperature research

**TOXICITY:** Cr (III): moderate acute toxicity to aquatic life, Cr (IV): high acute toxicity to aquatic life; both have high chronic toxicity to aquatic life; more toxic in soft water than in hard water

**EXPOSURE ROUTES:** wind transport from road dust; wood treated with copper dichromate; leather tanned with chromic sulfate; chromate production; stainless-steel production; chrome plating; working in tanning industries; chromium waste disposal sites; chromium manufacturing and processing plants; consumption of food and drinking water; inhalation of air

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** trivalent Cr: not to exceed  $\exp[1.08 \ln(\text{hardness}) + 3.48]$   $\mu\text{g/L}$ , hexavalent Cr: 0.29  $\mu\text{g/L/24 hr}$  avg., not to exceed 21.0  $\mu\text{g/L}$ ; **Criterion to protect saltwater aquatic life:** trivalent Cr: 10300  $\mu\text{g/L}$  based on acute toxicity, hexavalent Cr: 18  $\mu\text{g/L/24 hr}$  avg., not to exceed 1260  $\mu\text{g/L}$ ; **Criterion to protect human health:** trivalent Cr: 170  $\mu\text{g/L}$ , hexavalent Cr: 50  $\mu\text{g/L}$  according to EPA; long-term health advisory for adults: 0.84 mg/L; longtime health advisory: 0.12 mg/L; drinking water level proposed by EPA: 0.1 mg/L; limit in drinking water in Germany: 0.05 mg/L; MCGL: 0.1 mg/L; MCL: 0.1 mg/L; HAL (child): 1-10 day: 1 mg/L, longer term: 0.2 mg/L; the following are guidelines in drinking water set by some states: 50  $\mu\text{g/L}$  (Maine); 120  $\mu\text{g/L}$  (Minnesota)

**PROBABLE FATE: photolysis:** not an important process; **oxidation:** Cr (IV) slowly transformed to more stable Cr (III), Cr (II) oxidizes readily to Cr (III); **hydrolysis:** Cr (III) transformed to  $\text{Cr}(\text{OH})_3$  or  $\text{Cr}_2\text{O}_3$  (both insoluble at neutral or alkaline pH); **volatilization:** not important; **sorption:** Cr (IV) adsorbed by organic materials, sorption of Cr (III) ancillary to precipitation of  $\text{Cr}(\text{OH})_3$ ; **biological processes:** bioaccumulated by many aquatic organisms and passed on through the food chain, biotransformation is not important

**TREATABILITY/REMOVABILITY (Process, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): Gravity oil separation, not available, 1700; Gas flotation, 40-58, 300; Gas flotation with chemical addition (calcium chloride, polymer), 51-67, 330; Gas flotation with chemical addition (polymer), 0, negative removal; Gas flotation with chemical addition (alum, polymer), 19, 360; Filtration, 36->99, 67; Sedimentation, 79->99, 1200; Filtration,  $\text{Cr}^{+6}$ , 0, negative removal; Filtration,  $\text{Cr}^{+3}$ , 95, 610; Sedimentation with chemical addition (alum, lime), 72, 31; Sedimentation with chemical addition (lime, polymer), 86-98, 120; Sedimentation with chemical addition (sulfide), >97->99, 40; Sedimentation with chemical addition (polymer), >96-97, <14; Sedimentation with chemical addition (alum, polymer), 69-95, 70; Sedimentation with chemical addition (alum), 69-95, 95; Sedimentation with chemical addition (lime), 49-97, 340; Tertiary polishing lagoons, >71, <10; Aerated lagoons, 63-99, 380; Trickling Filters, 0, negative removal; Ultrafiltration, 67, 2900; Ozonation, 0, negative removal; Ion exchange, >99, 10; Activated sludge, 45-99, 910; Granular activated carbon adsorption, 34-95, 60; Reverse osmosis, 44->99, 460; Reverse osmosis  $\text{Cr}^{+6}$ , 0, negative removal; Reverse osmosis  $\text{Cr}^{+3}$ , >99, 15**

**KEY REFERENCES:** 19; 21; 23; 27; 28; 29

**CHRYSENE (C<sub>18</sub>H<sub>12</sub>, 228.3)**

**CAS/DOT IDENTIFICATION #:** 218-01-9/UN not available

**SYNONYMS:** 1,2-benzophenanthrene, 1,2,5,6-dibenzonaphthalene, benzo(a)phenanthrene, benz (a) phenanthrene

**PHYSICAL PROPERTIES:** red-blue, fluorescent rhombic plates from benzene, acetic acid; colorless platelets with blue fluorescence; MP (256°C); BP (448°C); DN (1.274 g/cm<sup>3</sup> @ 20°C); SG (1.274); VP (6.3x10<sup>-7</sup> mmHg); solubility in water (0.002 mg/L); Log Kow (5.61-5.91)

**CHEMICAL PROPERTIES:** very stable under normal lab conditions; sublimes easily under a vacuum

**BIOLOGICAL PROPERTIES:** chrysene at 5 ppm was 6% degraded with gradual adaptation after 7 days by microbes in settled domestic wastewater, 65%, 53%, 59% degraded after 7 days after addition of the 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> subculture, respectively; not degraded in 4 weeks in a suspension containing polluted water inoculum from a stream and either naphthalene or phenanthrene as a growth substrate; observed loss due to biodegradation in wastewater treatment plant: 9%; not expected to leach significantly into groundwater; may be subject to biodegradation in soil and water systems; soil and aerobic half-lives: 1.02-2.72 yrs; anaerobic half-life: 4.06-11 yrs; surface water half-life: 4.4-13 hrs; ground water half-life: 2.04-5.48 yrs; can be detected in water by extraction with methylene chloride followed by various measurements as reviewed in ATSDR (referenced below)

**BIOACCUMULATION:** will bioconcentrate in organisms which lack microsomal oxidase; evidence of bioconcentration in clams

**ORIGIN/INDUSTRY SOURCES/USES:** product of incomplete combustion; organic synthesis; research chemical

**TOXICITY:** Fish: *Neanthes arenaceodentata*: 96 hr TLm (seawater @ 22°C): >1 ppm (initial concentration in static assay)

**EXPOSURE ROUTES:** gasoline and diesel exhaust; cigarette smoke; coal tar; inhalation of contaminated air; skin contact; ingestion of contaminated food and foods like smoked or charcoal broiled meats and fish

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; Kansas guideline for drinking water: 0.029 µg/L

**PROBABLE FATE:** **photolysis:** very little specific data, but photolysis may claim some of the dissolved compound, atmospheric and aquatic photolytic half-life: 4.4-13 hrs, subject to near surface, direct photolysis with a half-life of 4.4 hrs, if released to air, it will be subject to direct photolysis, although adsorption may affect the rate, reaction with photochemically produced hydroxyl radicals gives an estimated half-life of gas phase chrysene of 1.25 hrs; **oxidation:** chlorine and/or ozone in sufficient quantities may oxidize chrysene, photooxidation half-life in air: 0.802-8.02 hrs; **hydrolysis:** not an important process; **volatilization:** probably too slow to compete with adsorption as a transport process, will not appreciably evaporate; **sorption:** adsorption onto suspended solids and sediment is the dominant transport process if released to soil or to water, expected to adsorb very strongly to the soil; **biological processes:** short-term bioaccumulation, metabolization and biodegradation are the principal fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Gravity oil separation*, not available, 11; *Sedimentation*, 0, negative removal; *Sedimentation with chemical addition (lime, polymer)*, 99, 10; *Sedimentation with chemical addition (lime)*, >92, <10; *Activated sludge* (based on synthetic wastewater), 65, 1750; *Continuous activated sludge biological treatment simulator*: 9% removal

**KEY REFERENCES:** 11; 21; 23; 24; 25; 26; 28; 30; 31

### **COPPER (Cu, 63.55)**

**CAS/DOT IDENTIFICATION #:** 7440-50-8/UN 1325, 1587

**SYNONYMS:** allbri natural copper, bronze powder, copper bronze

**PHYSICAL PROPERTIES:** reddish-brown metal; may form mono- and divalent compounds; insoluble in water; soluble in nitric acid and hot sulfuric acid; odorless; lustrous; ductile; malleable; MP (1080°C); BP (2600°C); SG (8.92); VP (1 mmHg @ 1628°C); solubility in water ( $7.06 \times 10^5$  @ 0°C ( $\text{CuCl}_2$ )); HV (1150 cal/g)

**CHEMICAL PROPERTIES:** on long standing a white deposit may form which is readily explodable peroxide; becomes dull when exposed to air; in moist air, gradually becomes coated with green basic carbonate

**BIOLOGICAL PROPERTIES:** all water is corrosive to copper to some degree, which depends primarily on the pH of the water; highly persistent in water, half-life >200 days; can be detected in water by digestion followed by atomic absorption or by colorimetry or by Inductively Coupled Plasma Optical Emission Spectrometry; dissolved form is detected by 0.45 $\mu$  filtration followed by the previous methods

**BIOACCUMULATION:** can be concentrated by the food chain; the concentration found in fish tissues is expected to be considerably higher than the average concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** electrical industry; gauges of wire for circuitry, coil, and armature windings; high conductivity tubes, commutator bars, etc.; water and gas piping; roofing materials; cooking utensils; chemical and pharmaceutical equipment; coinage; forms many alloys; compounds used as insecticides, algicides, molluscicides, plant fungicides, mordants, pigments, catalysts, analytical reagents; paints; electroplating; and many more uses

**TOXICITY:** high acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** inhalation of dust or fumes; ingestion; skin or eye contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 5.6  $\mu\text{g/L}/24$  hr avg., not to exceed  $\exp[0.94 \ln \{\text{hardness}\} - 1.23]$   $\mu\text{g/L}$ ; **Criterion to protect saltwater aquatic life:** 4.0  $\mu\text{g/L}/24$ -hr avg., not to exceed 23  $\mu\text{g/L}$ ; **Criterion to protect human health:** 1000  $\mu\text{g/L}$ ; MCGL: 1.3 mg/L; Action level: >1.3 mg/L in 10% or more of tap water samples; HAL (child): none; Czechoslovakia MAC in surface water: 0.1 mg/L, in drinking water: 0.05 mg/L; USSR and USSR-UNEP/IRPTC MAC in water used for domestic purposes: 1.0 mg/L and 0.001 mg/L in fresh water and 0.005 mg/L in seawater used for fishery purposes; the following

are guidelines in drinking water set by some states: 1000 µg/L (Kansas); 1300 µg/L (Minnesota)

**PROBABLE FATE:** *photolysis:* not an important process; *oxidation:* Cu(I) quickly oxidized in water, transformation Cu(II) to CuO and Cu<sub>2</sub>(OH)<sub>2</sub>CO<sub>3</sub> very pH-dependent; *hydrolysis:* CuO and Cu<sub>2</sub>(OH)<sub>2</sub>CO<sub>3</sub> formed, but less effective than sorption; *volatilization:* not an important process; *sorption:* sorbed by hydrous iron and manganese oxides, enhances by complexing with ligands; *biological processes:* bioaccumulated by all organisms, but not biomagnified, biotransformation not important

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 100; *Gas flotation*, 69, 5; *Gas flotation with chemical addition (calcium chloride, polymer)*, 78-91, 300; *Gas flotation with chemical addition (polymer)*, 42-75, 66; *Gas flotation with chemical addition (alum, polymer)*, 19, 660; *Filtration*, 40->99, 200; *Sedimentation*, 66->99, 73; *Sedimentation with chemical addition (alum, lime)*, 62-88, 36; *Sedimentation with chemical addition (lime, polymer)*, 87->99, 56; *Sedimentation with chemical addition (sulfide)*, >98->99, 260; *Sedimentation with chemical addition (polymer)*, 56->89, 140; *Sedimentation with chemical addition (alum, polymer)*, 49-80, 6900; *Sedimentation with chemical addition (alum)*, >64-81, <37; *Sedimentation with chemical addition (lime)*, 75->99, 52; *Tertiary polishing lagoons*, 0, negative removal; *Aerated lagoons*, 79-94, 40; *Trickling Filters*, 0, negative removal; *Ultrafiltration*, >73-90, <700; *Ozonation*, 0, negative removal; *Chemical oxidation (chlorination)*, 14, 320; *Ion exchange*, 98->99, 95; *Activated sludge*, 52->99, 43; *Granular activated carbon adsorption*, 47->85, <66; *Reverse osmosis*, 73->99, 1600

**KEY REFERENCES:** 11; 21; 23; 27; 31

### CYANIDE ((CN)<sup>-1</sup> and HCN, 26.02 and 27.03)

**CAS/DOT IDENTIFICATION #:** 57-12-5 for cyanide and 74-90-8 for HCN/UN 1588 for cyanide ion

**SYNONYMS:** carbon nitride ion, cyanide anion, isocyanide

**PHYSICAL PROPERTIES (HCN):** main form is hydrogen cyanide; colorless gas; faint bitter almond odor; soluble in ethanol; miscible in water; MP (-13.3°C); BP (25.6°C); DN (0.6884 g/cm<sup>3</sup> @ 20°C); VP (620 torr @ 20°C); solubility (soluble in all proportions @ 25°C); OT (0.58 ppm air); Log Kow (0.66)

**CHEMICAL PROPERTIES (HCN):** incompatible with strong oxidizers such as nitrates, chlorates, acids, and acid salts; FP (-17.8°C closed cup); AT (538°C); LFL/UFL (6%, 41%)

**BIOLOGICAL PROPERTIES:** Koc; 1-70 for most soluble forms; at pH less than 9.2, most free cyanide is expected to convert to HCN; highly volatile and biodegradable when released to water; have the potential to leach into groundwater; do not adsorb to soil; nitriles have the highest mobility in soil; can be detected in water by silver nitrate titration or colorimetric analysis using pyridine pyrazolone

**BIOACCUMULATION:** BCFs: <1-50 for most soluble forms; soluble cyanides are not expected to bioconcentrate; insoluble cyanide compounds generally have the potential to bioconcentrate

**ORIGIN/INDUSTRY SOURCES/USES:** HCN: production of organic chemicals; insecticide for fumigating enclosed spaces; gas chamber executions

**TOXICITY:** not available

**EXPOSURE ROUTES:** car exhaust; emissions from chemical processing and municipal waste incinerators; smoking; water from discharges from organic chemical industries, iron, and steel works; wastewater facilities; electroplating work; metallurgical work; fire fighting; steel manufacturing; metal cleaning industries; petroleum refineries; pharmaceuticals; tannery work; blacksmithing; photoengraving; photography; groundwater from landfills; inhalation; skin adsorption; ingestion; eye and skin contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 3.5 µg/L/24 hr avg., not to exceed 52 µg/L any time; **Criterion to protect saltwater aquatic life:** 30 µg/L based on acute toxicity, 2 µg/L based on chronic toxicity; **Criterion to protect human health:** 200µg/L; allowable daily intake for man: 8.4 mg/day; MCLG: 0.2 mg/L; MCL: 0.2 mg/L; HAL (child): 1-10 day and longer term: 0.2 mg/L; international drinking water standards: South African Bureau of standards: 10 µg/L; World Health Organization (WHO): 10 µg/L; Federal Republic of Germany: 50 µg/L; USSR-UNEP/IRPTC MAC: 100 µg/L in water bodies used for domestic purposes and 50 µg/L in water for fishery purposes; lifetime health advisory by EPA: 154 µg/L; the following are guidelines in drinking water set by some states: 160 µg/L (Arizona); 220 µg/L (Kansas)

**PROBABLE FATE:** **photolysis:** presence of titanium dioxide causes rapid photooxidation of cyanide ion, otherwise, only some metalocyanides are photodecomposed; **oxidation:** strong oxidizing agents are required to oxidize cyanides; **hydrolysis:** too slow to compete with other fate mechanisms, resistant to hydrolysis in soil or water; **volatilization:** HCN, which composes almost all the total cyanides under natural conditions, is very rapidly volatilized; **sorption:** cyanides are adsorbed by most materials, but high solubility precludes strong adsorption, soluble cyanide compounds such as HCN and KCN have low adsorption to soils with high pH, high carbonate, and low clay content, insoluble cyanide compounds such as Cu and Ag salts may adsorb to soils and sediments; **biological processes:** toxicity precludes bioaccumulation, almost all organisms biodegrade cyanides, but not as rapidly as volatilization

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 170; *Gas flotation*, 0, negative removal; *Gas flotation with chemical addition (calcium chloride, polymer)*, 2-5, 290; *Gas flotation with chemical addition (polymer)*, 14, 25; *Gas flotation with chemical addition (alum, polymer)*, >61, <10; *Filtration*, 10->99, 50; *Sedimentation*, 31->90, 330; *Sedimentation with chemical addition (alum, lime)*, >70-80, <17; *Sedimentation with chemical addition (lime, polymer)*, 69-89, 21; *Sedimentation with chemical addition (alum, polymer)*, 0, negative removal; *Sedimentation with chemical addition (lime)*, 0, negative removal; *Aerated lagoons*, 45-91, 100; *Trickling Filters*, 79, 16; *Ultrafiltration*, 0, negative removal; *Ozonation*, 81-99, 2100; *Chemical oxidation*, 84->99, 38; *Ion exchange*, >98->99, 65; *Activated sludge*, 18->90, 520; *Powdered activated carbon adsorption*, >62-69, <28; *Granular activated carbon adsorption*, 57->90, <20; *Reverse osmosis*, 43-97, 2200

**KEY REFERENCES:** 19; 21; 23; 29

**4,4-DDD (C<sub>14</sub>H<sub>10</sub>Cl<sub>4</sub>, 320.05)**

CAS/DOT IDENTIFICATION #: 75-54-8/UN 2761

**SYNONYMS:** Dichlorodiphenyldichloroethane, DDD, 1,1'-(2,2-dichloroethylidene)bis[4-chlorobenzene], p,p'-DDD, TDE, 1,1-Dichloro-2,2-bis(p-chlorophenyl)ethane, p,p'-TDE, Rhothane, 2,2-bis-(4-chlorophenyl)-1,1-dichloroethane, dilene, rothane

**PHYSICAL PROPERTIES:** colorless crystals or tan powder; insoluble in water; soluble in organic solvents; MP (112°C); BP (193°C); DN (1.385 g/ml); SG (1.385); VD (11); VP (10.2x10<sup>-7</sup> torr @ 30°C); solubility in water (0.02 mg/L @ 20°C); Log Kow (5.98)

**CHEMICAL PROPERTIES:** probably combustible; incompatible with strong oxidizing agents; not compatible with alkalies

**BIOLOGICAL PROPERTIES:** it will adsorb very strongly to soil if released to the soil; not expected to appreciably leach to the groundwater; ground water half-life: 70 days-31.3 yrs; surface water half-life: 2-15.6 yrs; can be transported to ground water in some instances; aerobic half-life: 2-15.6 yrs; anaerobic half-life: 70-294 days; can be detected in wastewater by EPA Methods 508, 608, 617, and 625

**BIOACCUMULATION:** will bioaccumulate in aquatic organisms if released to water

**ORIGIN/INDUSTRY SOURCES/USES:** derivation is from chlorination of ethanol and condensation with chlorobenzene; used to kill pests, but its use has also been banned; formerly used medically to treat cancer of the adrenal gland; non-degradable pesticide and a nonsystemic contact and systemic insecticide

**TOXICITY:** no data available

**EXPOSURE ROUTES:** primarily from eating contaminated foods, such as root and leafy vegetables, meat, fish, and poultry; inhalation of contaminated air near waste sites and landfills; swallowing soil particles near waste sites or landfills

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** no data available; **Criterion to protect saltwater aquatic life:** no data available; **Criterion to protect human health:** drinking water unit risk: 6.9E-6 µg/L; concentration calculated to keep the lifetime cancer risk level below 10<sup>-4</sup>, 10<sup>-5</sup>, and 10<sup>-6</sup> is 10, 1, and 0.1 µg/L respectively

**PROBABLE FATE:** **photolysis:** photooxidation to chlorinated biphenyls and benzophenones probable, indirect photolysis may be significant based on the behavior of the related compound DDT, direct photolysis half-life in water: >150 yrs, photooxidation half-life in air: 13.3-133 hrs; **oxidation:** not an important process, vapor phase half-life in the atmosphere: 1.71 days from reaction with photochemically produced hydroxyl radicals; **hydrolysis:** not an important process, will not hydrolyze in soil; **volatilization:** expected to be an important process, evaporation half-life: 1.82 days from a river 1 m deep, flowing at 1m/sec with a wind velocity of 3 m/sec; **sorption:** is an important process, expected to adsorb to sediment if released to water; **biological processes:** biotransformation and bioaccumulation are important processes; biodegradation expected to be slow

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), 0, not available; *continuous activated sludge biological treatment simulator:* removal was from 17%-100%; *fallout* and *washout* are major removal mechanisms from the air

**KEY REFERENCES:** 7, 23; 26; 28; 30; 31; 32

**4,4-DDE (C<sub>14</sub>H<sub>8</sub>Cl<sub>4</sub>, 318.08)**

**CAS/DOT IDENTIFICATION #:** 72-55-9/ UN not available

**SYNONYMS:** dichlorodophenyldichloroethylene, 1,1-dichloro-2,2-bis(p-chlorophenyl)-ethylene, 2,2-bis(4-chlorophenyl)-1,1-dichloroethylene, 2,2-bis(p-chlorophenyl)-1,1-dichloroethene, ddt dehydrochloride, p,p'-dichlorodiphenyl dichloroethylene

**PHYSICAL PROPERTIES:** white, crystalline solid; soluble in most organic solvents; MP (88-90°C); BP (316.5); VP (6.5x10<sup>-6</sup> torr @ 20°C); solubility (0.040 mg/L @ 20°C); Log Kow (7.0); Log Poct (4.28)

**CHEMICAL PROPERTIES:** sensitive to light; major metabolite of DDT; incompatible with strong oxidizing agents and strong bases; oxidation is catalyzed by UV radiation

**BIOLOGICAL PROPERTIES:** degrades further to DDA (bis(chlorophenyl)acetic acid) by loss of two molecules of HCl; persistence in river water under sunlight and fluorescent light in a sealed glass jar, initial concentration 10 µg/L, after 8 weeks, 100% of original compound found; found in bottom sediments of the North Sea, concentrations between 64 and 290 ppt; aerobic half-life: 2-15.6 yrs; anaerobic half-life: 16-100 days; surface water half-life: 6.1 days; ground water half-life: 16 days-31.3 yrs; can be detected in wastewater by EPA Methods 508, 608, 617, and 625

**BIOACCUMULATION:** found in human milk in Canada; persists in body fat; in aquatic vascular plants; goby fish (*Acanthogobius flavimanus*); Alaskan seal; marine animals from the Central Mediterranean and the Ligurian Sea; BCF (in aquatic model ecosystem): algae: 2,720, snail (*Cipangopaludina japonica Martens*): 13,700, carp (*Cyprinus carpio*): 8,450; BCF (in model ecosystem after 33 days @ 26°C): algae (*Oedogonium cardiacum*): 11,251, snail (*Physa*): 36,342, mosquito (*Culex pipens quinquefasciatus*): 59,390, fish (*Gambusia affinis*): 12,037

**ORIGIN/INDUSTRY SOURCES/USES:** DDT impurity; military product; pesticides; insecticide

**TOXICITY:** no data available

**EXPOSURE ROUTES:** eating contaminated foods, such as root and leafy vegetables, meat, fish, and poultry; inhalation of contaminated air or drinking contaminated water near waste sites and landfills; swallowing soil particles near waste sites or landfills

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** no data available; **Criterion to protect saltwater aquatic life:** no data available; **Criterion to protect human health:** oral unit risk estimate in drinking water: 9.7 × 10<sup>-6</sup> µg/L; concentration calculated to keep the lifetime cancer risk level below 10<sup>-4</sup>, 10<sup>-5</sup>, and 10<sup>-6</sup> is 10, 1, and 0.1 µg/L, respectively

**PROBABLE FATE:** **photolysis:** photooxidation to chlorinated biphenyls and chlorinated benzophenones occurs, could be important in aquatic systems, atmospheric and aqueous photolytic half-life: 6.1 days, photolytic half-life if released to ware: 15-26 hrs; **oxidation:** photooxidation half-life in air: 5.25-40.9 hrs, vapor phase half-life in the atmosphere: 4.63 hrs from reaction with photochemically produced hydroxyl radicals; **hydrolysis:** not an important process;

**volatilization:** probably an important process, evaporation from the surface of soils with low organic content like sandy soils expected to be significant, evaporation half-life: 5.6-6.4 hrs from a river 1 m deep, flowing at 1m/sec with a wind velocity of 3 m/sec; **sorption:** is an important process, will adsorb very strongly to soil if released onto the soil, will not be expected to leach through soil to groundwater, will adsorb very strongly to sediment if released to water; **biological processes:** bioaccumulation is an important process, will not significantly biodegrade

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption*, ~100, 0.002; *continuous activated sludge biological treatment simulator*: removal was 39%; *fallout* and *washout* are major removal mechanisms from the air

**KEY REFERENCES:** 13; 19; 23; 25; 26; 28; 30; 31; 32

#### 4,4-DDT ( $\text{C}_{14}\text{H}_9\text{Cl}_5$ , 354.5)

**CAS/DOT IDENTIFICATION #:** 50-29-3/UN 2761

**SYNONYMS:** p-p'-DDT, DDT, 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane, dichlorodiphenyltrichloroethane, dicophane, chlorophenothane, Gesarol®, Neocid®

**PHYSICAL PROPERTIES:** waxy solid; weak, chemical odor; tasteless; sinks in water; MP (107-109°C); BP (185°C); SG (1.56 @ 15°C); VP ( $1.9 \times 10^{-7}$  torr @ 20°C); solubility in water (0.006 mg/L @ 25°C); OT (0.2 ppm); Log Kow (3.987)

**CHEMICAL PROPERTIES:** incompatible with strong oxidizers; may react with iron, aluminum, aluminum and iron salts, and alkalies; incompatible with ferric chloride and aluminum chloride; FP (72-75°C)

**BIOLOGICAL PROPERTIES:** long term persistence in soil and water; sticks strongly to soil particles and does not leach rapidly into underground water; soil half-life: 2-15 yrs; aerobic half-life: 2-15.6 yrs; anaerobic half-life: 16-100 days; surface water half-life: 7-350 days; ground water half-life: 16-31.3 days; can be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** concentrated accumulation in the fat of wildlife and humans as a result of low water solubility and high lipophilicity; builds up in plants and in the fatty tissues of fish, birds, and animals

**ORIGIN/INDUSTRY SOURCES/USES:** manufactured chemical; used to control insects on agricultural crops and insects that carry diseases like malaria and typhus; ectoparasiticide; use was banned in USA in 1972

**TOXICITY:** no data available

**EXPOSURE ROUTES:** inhalation; skin adsorption; ingestion; eye and skin contact; eating contaminated foods, such as root and leafy vegetables, meat, fish, and poultry; inhalation of contaminated air or drinking contaminated water near waste sites and landfills; swallowing soil particles near waste sites or landfills

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life: 0.0010  $\mu\text{g/L}/24$  hr avg., concentration not to exceed 1.1  $\mu\text{g/L}$  any time, Criterion to protect saltwater

**aquatic life:** 0.0010 µg/L/24 hr avg., concentration not to exceed 0.13 µg/L any time; **Criterion to protect human health:** preferably 0; concentration calculated to keep the lifetime cancer risk level below  $10^{-5}$  is 0.24 ng/L; USSR MAC: 0.1 mg/L in water used for domestic purposes, 0 in surface water for fishing; Mexico MPC: 0.042 mg/L in drinking water, 0.006 mg/L in estuaries, 0.6 µg/L in coastal waters; the following are guidelines in drinking water set by some states: 0.83 µg/L (Maine), 0.42 µg/L (Kansas), 1.0 µg/L (Minnesota), 50 µg/L (Illinois)

**PROBABLE FATE:** *photolysis:* photooxidation to DDE occurs slowly, indirect photolysis may be important; *oxidation:* photooxidation occurs, photooxidation half-life in water: 7-350 days, photooxidation half-life in air: 7.4 days; *hydrolysis:* may be an important process under certain conditions, first-order hydrolytic half-life: 22 yrs; *volatilization:* is an important process, some will evaporate from soil and surface water into the air; *sorption:* is an important process, will adsorb very strongly to soil if released to the soil, will adsorb very strongly to sediments if released to water; *biological processes:* biotransformation and bioaccumulation are important processes, may be subject to biodegradation in flooded soils or under anaerobic conditions, may be significant in sediments

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Sedimentation with chemical addition (alum, lime)*, >52, <1; *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 0.008; *continuous activated sludge biological treatment simulator:* removal was 100%; *Wet and dry deposition* will be major removal mechanisms from the air

**KEY REFERENCES:** 21; 23; 26; 28; 30; 31

## DIBENZ(a,h)ANTHRACENE (C<sub>22</sub>H<sub>14</sub>, 278.36)

**CAS/DOT IDENTIFICATION #:** 53-70-3/UN 2811

**SYNONYMS:** 1,2,5,6-dibenzanthracene, DBA, 1,2:5,6-benzanthracene, db(a,h), dibenzo(a,h)anthracene

**PHYSICAL PROPERTIES:** colorless plates or leaflets (recrystallized) from acetic acid; white crystals; MP (270°C); BP (524°C, sublimes); DN (1.282); SG (1.282); VP ( $1 \times 10^{-1}$  mmHg (estimated)); solubility in water (0.0005 mg/L); Log Kow (6.50)

**CHEMICAL PROPERTIES:** can be hydrogenated to the octadecahydro derivative; can be oxidized by chromic acid to dibenz(a,h)anthra-7,14quinone, and to anthraquinone-1,2,5,6-tetracarboxylic acid; incompatible with strong oxidizers

**BIOLOGICAL PROPERTIES:** capable of long distance transport; not expected to leach into ground water; biodegradation in soil systems had half-lives of 18 and 21 days; biodegradation by microbes in settled domestic wastewater in original culture, 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> subcultures, respectively (7 days between each measurement and subculture): 1.10 ppm (82%), 1.18 ppm (82%), 1.14 ppm (82%), 1.22 ppm (75%); degradation using activated sludges showed 96% theoretical BOD in 144 hrs; microbial mineralization by 6 fresh composted municipal wastes in 10 weeks: 0.1-1.4%, average 0.4% measured by <sup>14</sup>CO<sub>2</sub> formation; soil and aerobic half-lives: 361 days-2.58 yrs; anaerobic half-life: 3.96-10.3 yrs; surface water half-life: 6 hrs-32.6 days; ground water half-life: 1.98-5.15 yrs; can be detected in water by methylene chloride extraction and may be followed by measurement by HPLC:NIOSH Method 5506 or gas chromatography: NIOSH Method 5515

**BIOACCUMULATION:** BCF (*Daphnia magna*): 652, 773; BCF (using Log Kow): 51,000; expected to bioconcentrate in aquatic organisms; may not bioconcentrate in aquatic organisms that contain microsomal oxidase, such as fish

**ORIGIN/INDUSTRY SOURCES/USES:** chemical substance formed during the incomplete burning of fossil fuel, garbage or any organic matter; component of coal tar pitch which is used as a binder for electrodes; component of creote used to preserve wood; asphalt; in gasoline; research chemical

**TOXICITY:** *Neanthes arenaceodentata*: 96 hr TLm in seawater @ 22°C: >1 ppm (initial concentration in static assay)

**EXPOSURE ROUTES:** cigarette smoke; exhaust from gasoline engines; airborne coal tar emissions; inhalation of contaminated air; consumption of contaminated food and water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** **Criterion to protect saltwater aquatic life:** **Criterion to protect human health:** 0; there are various levels proposed for various lifetime cancer risks: ingestion of contaminated water and aquatic organisms:  $1 \times 10^{-5}$ ,  $1 \times 10^{-6}$ ,  $1 \times 10^{-7}$ : 28 ng/L, 2.8 ng/L, 0.28 ng/L respectively; excluding consumption of contaminated water: 311 ng/L, 31.1 ng/L, 3.11 ng/L respectively; Kansas guideline in drinking water: 0.029 µg/L

**PROBABLE FATE:** **photolysis:** the dissolved portion of the compound may undergo rapid photolysis to quinones, atmospheric and aqueous photolytic half-lives: 6 hrs-32.6 days, may be subject to direct photolysis in the atmosphere, reaction with photochemically produced hydroxyl radicals has a half-life of 1.00 days; **oxidation:** rapid oxidation by chlorine and/or ozone may compete for dissolved DBA, photooxidation half-life in air: 0.428-4.28 hrs; **hydrolysis:** not an important process; **volatilization:** probably too slow to be important, rate uncertain; **sorption:** strong adsorption by suspended solids, especially organic particulates, should be the principal transport process; **biological processes:** bioaccumulation is short-term, metabolization and microbial biodegradation are the principal fates

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): no data on the removable range or the avg. achievable concentration in available; **Ozonation:** after 1 min. contact time with ozone: residual amount: 3.6%

**KEY REFERENCES:** 11; 21; 23; 25; 26; 28; 30

## DIBUTYLPHTHALATE (C<sub>16</sub>H<sub>22</sub>O<sub>4</sub>, 278.38)

**CAS/DOT IDENTIFICATION #:** 84-72-2/UN (NA9095)

**SYNONYMS:** Benzene-o-dicarboxylic acid di-n-butyl ester, 0-Benzenedicarboxylic acid, Dibutyl ester, n-Butyl phthalate (dot), Celluflex DPB, Dibutyl-1,2-benzenedicarboxylate, Di-n-butyl phthalate, Elaol, Hexaplas M/B, Palatinol C, Polycizer DBP, PX 104, Staflex DBP, Witcizer 300

**PHYSICAL PROPERTIES:** colorless, oily liquid; miscible with common organic solvents; insoluble with water; MP (-35 °C); BP (340 °C); DN (1.0484 @ 20 °/20 °C); VD (9.58); VS (0.203 poise @ 20 °C); VP (1.0 x 10<sup>-5</sup> mmHg @ 25 °C); Log Kow (5.60)

**CHEMICAL PROPERTIES:** stable; combustible; can react with oxidizing materials; incompatible with nitrates, strong alkalis, strong acids, and strong oxidizers; FP (312 °F); AT (750 °F); LEL (0.5% @ 235°C)

**BIOLOGICAL PROPERTIES:** ThOD: 2.24; aerobic degradation in freshwater hydrosoil: 53% after 24-hr incubation, 98% after 5 days incubation; degradation products found were mono-n-butylphthalate and phthalic acid after aerobic incubation, the latter compound was not present after anaerobic incubation; will be gone in 3-5 days in moderately polluted waters and generally within 3 weeks in cleaner bodies of water; if released onto soil, will moderately be adsorbed and will slowly biodegrade (66 and 98% degradation in 26 weeks from 2 soil samples); found in groundwater; subject to gravitational settling if released to air; soil and ground water half-lives: 2-23 days; surface water half-life: 1-14 days; aerobic half-life: 1-23 days; anaerobic half-life: 2-23 days; can be detected in water by EPA Method 606: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** will not bioconcentrate in fish; the concentration found in fish tissues is expected to be much higher than the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** nitrocellulose lacquers; elastomers; explosives; nail polish; solid rocket propellants; makes plastics soft and flexible; shower curtains; raincoats; food wraps; bowls; car interiors; vinyl fabrics; floor tiles; perfume fixative; textile lubricating agent; safety glass; insecticides; printing inks; paper coatings; adhesives; organic chemical industry

**TOXICITY:** Marine dinoflagellate (*Gymnodium breve*): 96 ht TLm: 0.02-0.6 ppm, 96 hr EC<sub>50</sub>: 0.0034-0.2 ppm; larvae of grass shrimp (*Palaemonetes Pugio Holthuis*): 17 days, LC<sub>50</sub>: 100 ppb-1 ppm and 24 hr, LC<sub>50</sub>: 10-50 ppm; no significant increase in mortality at 500 ppb after 32 days; grass shrimp (*Palaemonetes*): at 0.08 ppb: 3 day biomagnification factor: 5000 (0.4 ppm) based on C<sup>14</sup> incorporation

**EXPOSURE ROUTES:** primarily through food; ambient air; air of new cars and inside homes; vinyl floors; drinking water supplies; wastewater emissions during production and use

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 940 µg/L based on acute toxicity, 3µg/L based on chronic toxicity for all phthalate esters, 2,944 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** **Criterion to protect human health:** 34,000 µg/L; USSR-UNEP/IRPTC MAC: 0.2 mg/L in water bodies used for domestic purposes; the following are guidelines in drinking water set by some states: 2,200 µg/L (Maine); 770 µg/L (Kansas)

**PROBABLE FATE:** **photolysis:** no direct photolysis, indirect photolysis too slow to be environmentally important, photooxidation half-life in water: 2.4-12.2 yrs, photooxidation half-life in air: 7.4 hrs-2.5 days; **oxidation:** not important, reaction with photochemically produced hydroxyl radicals gives a half-life of 18 hrs; **hydrolysis:** hydrolysis (only in surface waters) believed to be too slow to be important, first-order hydrolytic half-life: 10 yrs; **volatilization:** not expected to be an important transport process; **sorption:** sorption onto particulates and complexation with organics are dominant transport processes; **biological processes:** bioaccumulated in many organisms, biodegraded rapidly in natural soil, some biotransformation, all biological processes are important fates

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 1.3; *Gas flotation with chemical addi-*

tion (calcium chloride, polymer), 39-79, 150; Gas flotation with chemical addition (polymer), >61->99, <5; Gas flotation with chemical addition (alum, polymer), 0, negative removal; Filtration, 16->99, 910; Sedimentation, 40->99, 42; Sedimentation with chemical addition (alum, lime), >99, <10; Sedimentation with chemical addition (lime, polymer), 99, 1; Sedimentation with chemical addition (polymer), 56->99, <6.4; Sedimentation with chemical addition (alum, polymer), >78->99, <8.5; Sedimentation with chemical addition (alum), 0, negative removal; Aerated lagoons, 0, negative removal; Ozonation, 77, 2.7; Activated sludge, 60->99, <9; Granular activated carbon adsorption, 62->99, 1.3; Reverse osmosis, 59-83, 0.9

**KEY REFERENCES:** 19; 21; 23; 25; 26; 27; 30

### 1,2-DICHLOROBENZENE (C<sub>6</sub>H<sub>4</sub>Cl<sub>2</sub>, 147.01)

**CAS/DOT IDENTIFICATION #:** 95-50-1/UN 1591

**SYNONYMS:** o-Dichlorobenzene, orthodichlorobenzene, Dowtherm E

**PHYSICAL PROPERTIES:** colorless liquid; pleasant aromatic odor; miscible with alcohol, ether, benzene; soluble in alcohol, ether, acetone, and benzene; solubility in water (156 mg/L @ 25°C); MP (-17.0 °C); BP (180.5 °C); DN (1.3048); SG (1.305); ST (37 dynes/cm); VD (5.07); VP (1.47 mmHg @ 25°C); HV (115 Btu, 2.68x10<sup>5</sup> J/kg); OT (50 ppm); Log Kow: (3.38); H (0.0012 atm·m<sup>3</sup>/mole @ 20°C)

**CHEMICAL PROPERTIES:** incompatible with strong oxidizers, hot aluminum or aluminum alloys; HC (-7969 Btu/lb); LFL/UFL (2%, 9%), AT (1198 °C)

**BIOLOGICAL PROPERTIES:** T.O.C.: 0.01 mg/L; Koc: 280-320; unfavorable taste in fish: <0.25 mg/L in water; moderately to tightly adsorbed into soil; BODs of 0%, 41%, and 51% of the theoretical BOD over 5, 10, and 20 days; slowly biodegraded in soil under aerobic conditions; not expected to be transformed in anaerobic water conditions in aquifers; slow biodegradation in natural water; degradation by *Pseudomonas*: 100% ring distribution of a 200 mg/L solution in 72 hr, mutant: 100% ring disruption in 26 hr; detection in water: EPA Methods 601, 602, and 612: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months

**BIOACCUMULATION:** Log<sub>10</sub> BCF: 4.17 based on green algae; BCF: 65-560 in fish; bluegill sunfish BCF: 66 after 28 day exposure in continuous flow system

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of 3,4-dichloro-aniline; solvent; dyes; fumigant and insecticide; metal polishes; industrial odor control, herbicides

**TOXICITY:** Toxicity threshold (cell multiplication test): bacteria (*Pseudomonas putida*): 15 mg/L, algae (*Microcystis aeruginosa*): 53 mg/L, green algae (*Scenedesmus quadricauda*): >100 mg/L, protozoa (*Uronema parduczi* Chatton-L-woff): 80 mg/L, protozoa (*Entosiphon sulcatum*): >64 mg/L, marine plankton: growth was stopped at 13 ppm; **Toxicity fish:** *Lepomis macrochirus*: static bioassay in fresh water @ 23 °C, mild aeration applied after 24 hr: best fit 96 hr LC<sub>50</sub>: 27 ppm, *Menidia beryllina*: best fit 96 hr LC<sub>50</sub>: 7.3 ppm, guppy (*Poecilia reticulata*): 14 d LC<sub>50</sub>: 5.9 ppm; fathead minnows: 72 hr LC<sub>100</sub>: 10 ppm and 72 hr LC<sub>0</sub>: 3 ppm

**EXPOSURE ROUTES:** oral consumption of contaminated drinking water and food, especially fish; inhalation of contaminated ambient air, skin adsorption

**REGULATORY STATUS:** MCLG: 0.6 mg/L; MCL 0.6 mg/L; HAL(child): 1 to 10 day: 9 mg/L, longer term: 9 mg/L; organoleptic limit USSR 1970: 0.002 mg/L, **Criterion to protect freshwater aquatic life:** 1,120 µg/L based on acute toxicity, 763 µg/L based on chronic toxicity, 44 µg/L/24 hr avg., not to exceed 99 µg/L at any time; **Criterion to protect saltwater aquatic life:** 1,970 µg/L based on acute toxicity, 15 µg/L/24 hr avg., not to exceed 34 µg/L at any time; **Criterion to protect human health:** 400 µg/L

**PROBABLE FATE:** *photolysis*: probably occurs slowly, in an isooctane solvent, it hardly adsorbs any radiation above 300 nm, direct photolysis in the environment should not be significant; *oxidation*: resistant to autooxidation by peroxy radical in water; oxidation by hydroxyl radicals occurs in atmosphere; photooxidation half-life in air: 6.4 days-63.7 days; *hydrolysis*: not important, first-order hydrolysis half-life: >879 years; *volatilization*: generally rapid volatilization occurs, half-life: <9 hr, volatilization from soil surfaces may be an important transport mechanism; *sorption*: significant amount of adsorption by organic materials expected in environment; *biological processes*: bioaccumulated more than chlorobenzene, volatilization is more important than biodegradation; will wash out in rain water

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Coal flotation with chemical addition (calcium chloride polymer)*, 76, 260; *Filtration*, 50->94, 3.8; *Sedimentation with chemical addition (alum, lime)*, >99, <0.05; *Sedimentation with chemical addition (alum)*, 25->50, <12; *Aerated lagoons*, >96, <10; *Granular activated carbon adsorption*, >99, <0.05; in a continuous flow activated sludge system, about 100% removal (78% biodegradation, 22% stripping) was reported

**KEY REFERENCES:** 11; 21; 22; 23; 24; 25; 26; 29

### 1,3-DICHLOROBENZENE (C<sub>6</sub>H<sub>4</sub>Cl<sub>2</sub>, 147.01)

**CAS/DOT IDENTIFICATION #:** 541-73-1/UN 9255

**SYNONYMS:** m-dichlorobenzene, metadichlorobenzene, 1,3-DCB

**PHYSICAL PROPERTIES:** liquid; solubility (123 mg/L @ 25°C); MP (-24.8°C); BP (172 °C), DN (1.29 g/ml @ 20°C); SG (1.288); ST (36.01 dynes/cm); VD (5.08); VP (2.28 torr @ 25°C); HV (62.79 cal/g); OT (0.02 ppm); critical pressure (38.3 atm); Log Poct (3.38); H (2.63 x 10<sup>-3</sup> atm·m<sup>3</sup>·mole<sup>-1</sup>), refractive index (1.5459 @ 20°C)

**CHEMICAL PROPERTIES:** combustible; incompatible with oxidizing agents and aluminum and its alloys; explosive vapor-air mixtures may be formed above the flash point; FP (67°C); AT (648 °C); LEL/UEL (2.02%, 9.2%); HC (4498 cal/g); HF (20.55 cal/g)

**BIOLOGICAL PROPERTIES:** T.O.C.: 0.02 mg/L; moderately to strongly adsorbed if released on soil; leachates from hazardous waste disposal areas and is detected in groundwater; possible slow biodegradation in soil under aerobic conditions; aerobic biodegradation in water is possible; anaerobic biodegradation not expected to occur; degradation by *Pseudomonas*: 100% ring distribution at 30 °C of a 200 mg/L solution in 96 hr, mutant: 100% ring disruption in 28 hr; can be detected in water by EPA Methods 601, 602, 612: gas chromatography or EPA Method 625: gas chromatography plus mass spectrometry; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months

**BIOACCUMULATION:** BCF: 89-740, detected in fish from Lake Ontario; the concentration found in fish tissues is expected to be slightly higher than the average concentration in the water the fish were taken from

**ORIGIN/INDUSTRY SOURCES/USES:** not a natural product; extensive information on the production and use is not available; fumigant; insecticide; intermediate: used in production of other chemicals; solvent; may exist as a contaminant of 1,2-dichlorobenzene and 1,4-dichlorobenzene formulations

**TOXICITY:** guppy (*Poecilia reticulata*): 14 d LC<sub>50</sub>: 7.4 ppm

**EXPOSURE ROUTES:** inhalation; ingestion; drinking water accounts for 35% of exposure; eating contaminated fish accounts for 65% of exposure

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 1,120 µg/L based on acute toxicity and 763 µg/L based on chronic toxicity; 310 µg/L/24 hr avg., concentration not to exceed 700 µg/L at any time; **Criterion to protect saltwater aquatic life:** 1,970 µg/L based on acute toxicity; 22µg/L/24 hr avg., concentration not to exceed 49 µg/L at any time; **Criterion to protect human health:** 400 µg/L; lifetime health advisory derived by USEPA: 0.62 mg/L; the following are standards and guidelines in drinking water set by some states: 130 µg/L (California), 620µg/L (Kansas), 600 µg/L (New Jersey); 1250 (Wisconsin)

**PROBABLE FATE:** **photolysis:** expected to occur slowly; **oxidation:** no data available on aqueous oxidation, oxidized by hydroxyl radicals in atmosphere; **hydrolysis:** not important process; first-order hydrolytic half-life: >879 yrs; **volatilization:** volatilizes at a relatively rapid rate, half-life is about 10 hr; volatilization from soil surfaces is expected to be a significant transport mechanism; **sorption:** sorbed by organic materials; adsorption to sediment expected to be a major environmental fate process based on research in the Great Lakes area; **biological processes:** bioaccumulates more than chlorobenzene, biodegradation is not as significant as volatilization; slightly persistent in water, half-life: 2-20 days; approximately 98.5% of 1,3-dichlorobenzene ends up in air; 1% ends up in water; the rest is divided equally between terrestrial soils and aquatic sediments.

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 3; *Gas flotation with chemical addition*, 76, 260; *Activated sludge* (based on synthetic wastewater), 69, 1550; *Powdered activated carbon adsorption* (based on synthetic wastewater), 98, 480

**KEY REFERENCES:** 21; 22; 23; 24; 25; 26; 27; 28

## 1,4-DICHLOROBENZENE (C<sub>6</sub>H<sub>4</sub>Cl<sub>2</sub>, 147.02)

**CAS/DOT IDENTIFICATION #:** 106-46-7/UN 1592

**SYNONYMS:** di-chloride, globol, p-chlorophenyl chloride, p-dichlorobenzene, p-dichlorobenzol, para crystals, paracide, paradi, paradichlorobenzene, paradow, paramoth, paranuggets, parazene, pdb, santochlor

**PHYSICAL PROPERTIES:** colorless crystals; moth-ball like odor; sweet taste; soluble in chloroform, carbon disulfide, alcohol, ether, acetone, benzene; insoluble in water; MP (53 °C); BP (174 °C); DN (1.2475 g/mL @ 20°C); SG (1.241); OT (0.18 ppm); ST (34.66 dynes/cm @ 20°C); VD (5.07); VS (0.839 mN/m-2 @ 55°C); VP (10 mmHg @54.8°C); HV (17,620.5

cal/g); solubility (65.3 mg/L @ 25°C); Log Kow (3.52); H (2.72 x 10<sup>-3</sup> atm·m<sup>3</sup>·mole<sup>-1</sup>); Log Poct (3.39 @ 20°C)

**CHEMICAL PROPERTIES:** volatile; combustible; reacts strongly with oxidizing agents, aluminum and its alloys; FP (65°C); LFL/UFL (1.8%, 7.8%); AT (647°C)

**BIOLOGICAL PROPERTIES:** T.O.C.: 0.03 mg/L moderately to tightly adsorbed if released to soil; leaching can occur; slow probable biodegradation in soil under anaerobic conditions; aerobic biodegradation in water probable; degradation by *Pseudomonas*: 100% ring distribution of a 200 mg/L solution in 72 hr, mutant: 100% ring distribution in 25 hr; detection in water: EPA Methods 601, 602, and 612: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months

**BIOACCUMULATION:** Koc: 409-1514; BCF: ranges from 100-250 in various species, experimental BCF: <1000; significant bioconcentration will not occur; one study showed BCF (guppies): 1800; BCF (bacteria) 20; bioaccumulation increases with Log Poct until reaching a maximum of 6.5

**ORIGIN/INDUSTRY SOURCES/USES:** fumigant; germicide; additive to resin-bonded abrasive wheels; used in dyes; pharmaceuticals; odorant for toilets, pig pens, refuse containers

**TOXICITY:** guppy (*Poecilia reticulata*): 14 d, LC<sub>50</sub>: 4.0 ppm; fathead minnows (*Pimephales promelas*): 24 hr LC<sub>50</sub>: 35.4 mg/L, 48 hr LC<sub>50</sub>: 35.4 mg/L, 96 hr LC<sub>50</sub>: 33.7 mg/L; grass shrimp (*Palaemonetes pugio*): 48 hr LC<sub>50</sub>: 129 mg/L, 96 hr LC<sub>50</sub>: 69 mg/L; bluegill sunfish (*Lepomis macrochirus*): LC<sub>50</sub>: 4.54 mg/L/24 hr, 4.3 mg/L/48 hr, 4.25 mg/L/96 hr

**EXPOSURE ROUTES:** ingestion; inhalation; eye and skin contact; direct manufacturing effluents, chemical waste dump leachates

**REGULATORY STATUS:** MCLG: 0.075 mg/L; MCL: 0.075 mg/L, HAL(child): 1 day: 10 mg/L, longer-term: 10 mg/L; organoleptic limit USSR 1970: 0.002 mg/L; **Criterion to protect freshwater aquatic life:** 1,120 µg/L based on acute toxicity, 763 µg/L based on chronic toxicity, 190 µg/L/24 hr avg., concentration not to exceed 440 µg/L any time; **Criterion to protect saltwater aquatic life:** 1,970 µg/L based on acute toxicity, 15 µg/L/24 hr avg., concentration not to exceed 49 µg/L any time; **Criterion to protect human health:** 400 µg/L

**PROBABLE FATE:** *photolysis*: probably occurs slowly; will react with photochemically produced hydroxyl radicals with a half-life of 31 days; *oxidation*: resistant to autooxidation by peroxy radical in water, oxidized by hydroxy radicals in atmosphere; *hydrolysis*: unimportant process; first-order hydroxyl half-life: >879 yrs; *volatilization*: volatilizes at a relatively rapid rate; volatilization half-life: <24 hr; *sorption*: probably absorbed by organic materials; adsorption to sediment is a major environmental fate process; *biological processes*: bioaccumulates more than chlorobenzene, too resistant to biodegradation to compete with volatilization; will wash out in rain water

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gas flotation with chemical addition (calcium chloride, polymer)*, 76, 260; *Aerated lagoons*, >81, <10; *Activated sludge*, >82->99, <5; *Powdered activated carbon adsorption* (based on synthetic wastewater), 98, 330

**KEY REFERENCES:** 11; 19; 21; 22; 23; 24; 25; 26; 29

**3,3-DICHLOROBENZIDINE (C<sub>12</sub>H<sub>10</sub>Cl<sub>2</sub>N<sub>2</sub>, 253.14)****CAS/DOT IDENTIFICATION #:** 94-91-1/UN not available**SYNONYMS:** DCB, 4,4'-diamino-3,3'-dichlorobiphenyl, 4,4'-diamino-3,3'-dichlorodiphenyl, dichlorobenzidine,**PHYSICAL PROPERTIES:** gray or purple crystalline solid; insoluble in water; soluble in benzene, diethyl ether, ethanol, glacial acetic acid; MP (133°C); BP (402°C); VP (1.15x10<sup>-7</sup> mmHg @ 25°C); water solubility (3.1 mg/L @ 25°C); Log Kow (3.64); H (4.5x10<sup>-8</sup> atm<sup>3</sup>/mole @ 25°C)**CHEMICAL PROPERTIES:** nonflammable; decomposes on heating; formation of diazonium salts and alkali derivatives; weak base**BIOLOGICAL PROPERTIES:** degradation: after 1 month incubation period, @ 21°C in the dark: 75% of the original compound still present; no metabolites detected; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months; can be detected in water by EPA Method 605: chloroform extraction followed by concentration and high performance liquid chromatography, or EPA Method 625: gas chromatography plus mass spectrometry**BIOACCUMULATION:** will bioconcentrate in fish; BCF (golden ide and algae): 610 and 940 respectively; BCF (bluegill sunfish): 500; bluegills (*Lepomis macrochirus*): concentration in water: 2.0, in whole body: 265 after 48 hr exposure, concentration in water: 0.5, in whole body: 277 after 120 hr exposure**ORIGIN/INDUSTRY SOURCES/USES:** manufacture azo dyes, rubber and plastic, printing ink, textiles, crayons; curing agent; isocyanate-containing polymers; solid urethane plastics; detection of gold; production of pigments; substitutes for lead chromate pigments**TOXICITY:** data not available**EXPOSURE ROUTES:** low levels in water; pressurized spray containers or paints; lacquers; enamels; dyes; workers in garment and leather industries; printing and paper industries; homecraft industries; inhalation; percutaneous adsorption; emissions; wastewater**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; concentration calculated to keep the lifetime cancer risk level below 10<sup>-5</sup> is 0.103 µg/L; concentration calculated to keep the lifetime cancer risk level below 10<sup>-6</sup> is 0.010 µg/L; concentration calculated to keep the lifetime cancer risk level below 10<sup>-7</sup> is 0.001 µg/L; the following are guidelines in drinking water set by some states: 0.21 µg/L(Kansas and Minnesota)**PROBABLE FATE:** **photolysis:** in shallow water; conversion to 3-dichlorobenzidine by rapid photolysis, half-life: 90 sec in distilled water; atmospheric and aqueous photolytic half-life: 1.5-4.5 min, irradiation with light yields monochlorobenzene and benzidine; **oxidation:** oxidized like benzidine, especially by metal cations, but not as easily, photooxidation half-life in water: 1.3-72.5 days, photooxidation half-life in air: 0.905-9.05 hrs; **hydrolysis:** not an important process; **volatilization:** not an important process; **sorption:** adsorption by clay minerals, possible most important transport process, irreversible sorption on suspended particles and chemical degradation within the sediments; **biological processes:** microbial degradation is not significant; using sewage seed, 9-99% degraded in 28 days when yeast extract was present at concentrations of 50 to 400 mg/L; no degradation occurred without the nutrient; incubated with natural aquatic

communities from eutrophic and mesotrophic lakes, 25% degraded in 1 month; incubated in soil under aerobic conditions, 2% mineralization occurred in 32 weeks and no degradation intermediates were detected; under anaerobic conditions, no mineralization occurred in a year; *redox reactions* and reactions involving free radicals may be important

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 5; *granular activated carbon* and *chemical oxidation* are other treatment alternatives for contaminated water; for contaminated soil, *well point collection* and *treatment of leachates*

**KEY REFERENCES:** 11; 19; 21; 22; 23; 24; 25; 26

### DICHLOROBROMOMETHANE ( $\text{BrCHCl}_2$ , 163.8)

**CAS/DOT IDENTIFICATION #:** 75-27-4/UN not available

**SYNONYMS:** bromodichloromethane, BDCM, methane, bromodichloro, monobromodichloromethane

**PHYSICAL PROPERTIES:** colorless liquid; soluble in chloroform; very soluble in water; miscible in organic solvents; soluble in ether, benzene, and lipids; MP ( $-57.1^\circ\text{C}$ ); BP ( $90^\circ\text{C}$ ); DN ( $1.948\text{ g/cm}^3$ ); SG (1.971); VP (50 torr @  $20^\circ\text{C}$ ); solubility in water (4700 ppm @  $22^\circ\text{C}$ ); Log Kow (1.88); H ( $2.12 \times 10^{-3}\text{ atm}\cdot\text{m}^3/\text{mole}$ ); refractive index (1.4964 @  $20^\circ\text{C}$ )

**CHEMICAL PROPERTIES:** nonflammable; may react with strong bases and magnesium; incompatible with oxidizing materials

**BIOLOGICAL PROPERTIES:** moderately to highly mobile in soil; has the ability to leach into ground water; long range global transport is possible; non-persistent in water, half-life: <2 days due to volatilization; a single oral dose of 20 mg/kg in rats is cleared very quickly; in monkeys, half-life of a similar dose: 4-6 hrs; biodegradation loss: 51-99% using static flask screening procedures and 28 days incubation; significant biodegradation with gradual adaptation; in anaerobic tests using mixed methanogenic bacterial cultures from sewage effluents: totally degraded within 2 weeks, only 43-50% was lost in sterile controls after 6 weeks; under anoxic conditions with denitrifying bacteria: 50% degradation in bacterial cultures after 8 weeks but none in sterile controls; can be detected in water by EPA Method 601: gas chromatography, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** Log BCF (based on solubility and Log Kow): 0.72-1.37; the concentration found in fish tissues is expected to be somewhat higher than the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** results from the chlorination of finished water; is biosynthesized and emitted to environment by marine microalgae in the ocean; lab use; organic synthesis; fire-extinguisher fluid ingredient; solvent in fats, waxes, and resins; heavy liquid for mineral and salt separations; fire retardant

**TOXICITY:** moderate acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** consumption of contaminated drinking water, beverages, and food products; inhalation of contaminated ambient air; through dermal contact with chlorinated swimming pool water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** 0.100 mg/L; ambient water quality level suggested by EPA: 0; lifetime cancer risk of 1 in 100,000: 1.9µg/L; MCL(trihalomethanes): 0.10 mg/L; the following are guidelines in drinking water set by some states: 1.0 µg/L (Illinois); 100 µg/L (Vermont)

**PROBABLE FATE:** **photolysis:** could be important, direct photolysis does not occur below the ozone layer, if released to air, the transformation process in the troposphere is reactor with hydroxyl radicals, with an estimated half-life of 6.65 months; **oxidation:** could occur; **hydrolysis:** too slow to be important; **volatilization:** volatilization has been demonstrated, probably an important transport mechanism, if released to water or soil, volatilization will be the dominant fate process, volatilization half-life from rivers and streams: 33 min to 12 days with a typical half-life of 35 hrs; **sorption:** no information, but adsorption onto activated carbon has been demonstrated; **biological processes:** moderate potential for bioaccumulation, metabolization by some aquatic life is known to occur, anaerobic biodegradation may be the major removal process in aquatic regions where volatilization is not possible; **other reactions/interactions:** may be formed by a haloform reaction following chlorination of drinking water if sufficient bromide is present

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gas flotation with chemical addition (alum, polymer)*, >85, <0.9; *Activated sludge*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), 59, 2050; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 11; atmospheric removal via *washout* can occur

**KEY REFERENCES:** 11; 21; 23; 25; 27; 28; 30

### 1,1-DICHLOROETHANE (C<sub>2</sub>H<sub>4</sub>Cl<sub>2</sub>, 98.96)

**CAS/DOT IDENTIFICATION #:** 75-34-3/UN 2362

**SYNONYMS:** ethylidene dichloride, chlorinated hydrochloric ether, ethylidene chloride

**PHYSICAL PROPERTIES:** colorless, oily liquid; chloroform-like odor; saccharine-like taste; MP (-98°C); BP (57-59°C); DN (1.174 g/ml @ 17°C); SG (1.174 @ 20°C); ST (24.75 dynes/cm); VD (3.42); VP (234 mm @ 25°C); OT (120 ppm); HV (73.1 cal/g); solubility (5,500 mg/L @ 20°C); Log Kow (1.79); H (5.87 x 10<sup>-3</sup> atm-m<sup>3</sup>/mole); Refractive index (1.4166 @20°C); critical temperature (261.5°C); critical pressure (734.8 psia)

**CHEMICAL PROPERTIES:** volatile; reacts violently with strong oxidizing agents; incompatible with strong caustic substances; HC (-2,652 cal/g); FP (-6°C); LFL/UFL: (5.6%, 11.4%); AT (458°C)

**BIOLOGICAL PROPERTIES:** BOD<sub>5</sub>: 0.002; BOD<sub>10</sub>: 0.05; BCF: 1.2; Koc: 40; evaporation rate: 11.6; biodegradability data is unavailable but may be possible; aerobic half-life: 32 days-22 weeks; anaerobic half-life: 128 days-88 weeks; can be detected in water by EPA method 601: inert gas purge followed by gas chromatography with halide specific detection or EPA method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** bioconcentration in aquatic organisms is not important and not expected

**ORIGIN/INDUSTRY SOURCES/USES:** not a natural product; released into the environment as fugitive emissions and in wastewater during production and use as an intermediate and solvent; coupling agent in antiknock gasoline; paint; varnish; metal degreasing; ore flotation agent

**TOXICITY:** Arthropods: brine shrimp: 24 hr TLM: 320 mg/L; **Toxicity (Fish):** pin-perch: 24 hr TLM: 160 mg/L; guppy (*Poecilia reticulata*): 7 d LC<sub>50</sub>: 202 ppm

**EXPOSURE ROUTES:** inhalation to workers and people living near source areas; ambient air

**REGULATORY STATUS:** insufficient data to set criterion for aquatic life or human health; the following are standards or guidelines set by some states: 1.0 µg/L (Illinois), 20.0 µg/L (California), 25 µg/L (New Mexico), 70.0 µg/L (Vermont), and 850 µg/L (Wisconsin)

**PROBABLE FATE:** *photolysis:* information lacking, photodissociation to chloroacetyl chloride in stratosphere is predicted; *oxidation:* photooxidation in troposphere may be the predominant fate, photooxidation in aquatic environments probably occurs at a slow rate; *hydrolysis:* unimportant compared to volatilization; *volatilization:* due to high vapor pressure, volatilization to the atmosphere should be the major transport process, if released in water, will be removed by volatilization with a half-life of: 6-9 days, 5-8 days, and 23-32 hr, in a typical pond, lake, or river respectively, will be removed quickly by volatilization if released on land; *biological processes:* data is lacking, bioaccumulation not expected, biodegradation may be possible; *evaporation* from water @ 25°C of 1 ppm solution: 50% after 22 min, 90% after 109 min.

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 1; *Filtration*, 0, negative removal; *Sedimentation*, >0, <10; *Activated sludge*, >9->18, <3.5; *Granular activated carbon adsorption*, >89->99, 8,100; will be removed in the rain; bank filtration, passing river water through soil, removed the concentration by 25%

**KEY REFERENCES:** 19,21,22,23,25,26,28

## 1,2-DICHLOROETHANE (C<sub>2</sub>H<sub>4</sub>Cl<sub>2</sub>, 98.96)

**CAS/DOT IDENTIFICATION #:** 107-06-2/UN 1184

**SYNONYMS:** ethylene dichloride, ethane-dichloride, ethyleendichloride, freon-150, glycol dichloride

**PHYSICAL PROPERTIES:** clear, colorless, oily liquid; pleasant odor; sweet taste; soluble in organic solvents; MP (-35 °C); BP (83 °C); DN (1.2351 g/mL @ 20°C); SG (1.256); VD (3.4); VP (100 mm @ 29.4 °C); HV (76.4 cal/g); OT (100 ppm); solubility (0.869 g/100 mL @ 20°C); Log Kow (1.48); H (1.10 x 10<sup>-3</sup> atm·m<sup>3</sup>·mole<sup>-1</sup>)

**CHEMICAL PROPERTIES:** stable in presence of alkalis and acids; corrodes iron and other metals at elevated temperatures when in contact with water; combustible; incompatible with strong oxidizers, strong caustics, and chemically active metals; FP (15 °C); LFL/UFL (6.2%, 15.6%); AT (413 °C)

**BIOLOGICAL PROPERTIES:** COD: 1.025, ThOD: 0.97; Koc for silt loam: 33; rapidly percolates through sandy soil; little adsorption to soil is expected; can be detected in water

by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection or by EPA Method 624: gas chromatography plus mass spectrometry; aerobic half-life 100 days-6 months; anaerobic half-life: 400 days-24 months; little or no biodegradation in aerobic systems using sewage seed or activated sludge

**BIOACCUMULATION:** not expected to bioconcentrate in fish due to its low Log K<sub>ow</sub> measured Log BCF in bluegill sunfish: 0.30; presence in some foods probably due to use as an extractant

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of acetyl cellulose, ethylene glycol, varnish, organic compounds, pharmaceuticals, resins; paint; soaps; leather cleaning; degreasing agent; rubber cement; photography; extracting agent for soybean oil and caffeine; pickling agent; water softening

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria: 135 mg/L; algae: 105 mg/L, green algae: 710 mg/L, protozoa (*Entosiphon sulcatum*): 1127 mg/L, protozoa (*Uronema parduczi Chatton-Lwoff*): 1050 mg/L; **Toxicity fish:** fathead minnow: LC<sub>50</sub>: 500 ppm, rainbow trout, bluegill: no effect level: 5 ppm 24 hr, dab (*Limanda limanda*): no effect at 60 mg/L after 96 hr exposure, guppy: 7 d LC<sub>50</sub>: 106 ppm

**EXPOSURE ROUTES:** primarily inhalation; ingestion; adsorption through skin and eyes

**REGULATORY STATUS:** MCLG: 0 mg/L; MCL: 0.005 mg/L; HAL(child): 0.7 mg/L: 1-10 days and longer term; concentration calculated to keep the lifetime cancer risk level below 10<sup>-5</sup> is 9.4 µg/L; EPA longer term health advisory (adult): 2.6 mg/L; **Criterion to protect freshwater aquatic life:** 118,000 µg/L: acute toxicity, 20,000 µg/L: chronic toxicity; 3,900 µg/L/24 hr avg., not to exceed 8,800 µg/L any time; **Criterion to protect saltwater aquatic life:** 113,000 µg/L: acute toxicity; 880 µg/L/24 hr avg., not to exceed 2,000 µg/L any time; **Criterion to protect human health:** 0 µg/L; standards and guidelines in drinking water set by some states are: 2 µg/L (NJ), 3 µg/L (FL), 10 µg/L (NM), 0.38 µg/L (NH), 1 µg/L (CA, CT), 3.8 µg/L (MN), 5 µg/L (ME); water quality: in 11 raw water locations in U.S.: <0.2-31 µg/L, in 26 finished water locations: 0.2-6 µg/L

**PROBABLE FATE:** **photolysis:** direct photolysis is not significant, photodissociation in stratosphere to chloroacetyl chloride; **oxidation:** photooxidation in water expected to be slow; primarily removed in air by photooxidation; degraded in atmosphere by reaction with hydroxyl radicals, half-life of 1 month and 1.9% loss/12 hr sunlit day; products of photooxidation: CO<sub>2</sub> and HCl; oxidation half-life: 1.5 weeks-4 months; **hydrolysis:** not significant; first-order hydrolytic half-life: 1.1 yr; **volatilization:** high vapor pressure causes rapid volatilization, major transport process, half-life: 30 min @ 25°C; **evaporation:** primary removal from water; half-life from 1 ppm solution @ 25°C, still air, and an avg. depth of 6.5 cm: 28 min., evaporation from water @ 25 °C of 1 ppm solution: 50% after 29 min. and 90% after 96 min.

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Filtration*, 0, negative removal; *Sedimentation* >70, <10; *Sedimentation with chemical addition (alum, polymer)*, 30->60, <50; *Sedimentation with chemical addition (alum)*, 0, negative removal; *Steam stripping*, 97->99, 33000; *Solvent extraction*, 87->99, 84000; *Powdered activated carbon adsorption*, 81, 190000; *Granular activated carbon adsorption*, >86->99, 230000

**KEY REFERENCES:** 11; 19; 21; 22; 23; 24; 25; 26; 29

**1,1-DICHLOROETHYLENE (CH<sub>2</sub>=CCl<sub>2</sub>, 96.94)****CAS/DOT IDENTIFICATION #:** 75-35-4/UN 1303**SYNONYMS:** vinylidene chloride, 1-1-DCE, 1,1-dichloroethene, VDC, vinylidene dichloride, DCE**PHYSICAL PROPERTIES:** colorless liquid; mild, sweet odor; OT (190 ppm); practically insoluble in water; solubility in water (5,000 mg/L @ 20°C); soluble in organic solvents; MP (-12 °C); BP (31.6 °C); SG (1.213); VD (3.46); VP (591 mmHg @ 25 °C); Log Kow (2.13); H (15.0 x 10<sup>-3</sup> atm·m<sup>3</sup>/mole)**CHEMICAL PROPERTIES:** polymerizes to a plastic; incompatible with oxidizing agents, copper, aluminum, and peroxides; reacts with alcohols and halides; FP (-15 °C); AT (519 °C); LFL/UFL (6.5%, 15.5%)**BIOLOGICAL PROPERTIES:** T.O.C.: 500 ppm; Koc: 150; under anaerobic conditions, reductive dechlorination to vinyl chloride occurs; under simulated anaerobic landfill conditions, degradation occurred in 1-3 weeks; detection in water is by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection, and by EPA Method 624: gas chromatography plus mass spectrometry; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 81 days-173 days**BIOACCUMULATION:** will probably not bioconcentrate in fish; predicted to be a little higher in fish tissues than the water the fish was in; in microorganisms used to simulate anaerobic conditions, 50% of the pollutant disappeared in 5-6 months**ORIGIN/INDUSTRY SOURCES/USES:** not a natural product; formed by the anaerobic biodegradation of trichloroethylene and by the hydrolysis of 1,1,1-trichloroethane; manufacturer of polyvinylidene copolymers and methyl chloroform; flexible films for food packing (Saran<sup>®</sup> and Velon<sup>®</sup> wraps); flame retardant coatings for fiber and carpet backing in pipes; coating for steel pipes; adhesive applications**TOXICITY: Fish:** *Lepomis macrochirus*: static bioassay in fresh water @ 23 °C, mild aeration applied after 24 hr, best fit 96 hr LC<sub>50</sub> is 220 ppm; *Menidia beryllina*: static bioassay in synthetic seawater at 23°C, mild aeration applied after 24 hr, best fit 96 hr LC<sub>50</sub> is 250 ppm**EXPOSURE ROUTES:** major exposure is from occupational areas; food which contacted plastic wrap which has residual monomer; air releases; emissions from polymer synthesis and fabrication industries; inhalation or dermal contact in workplace; drinking water**REGULATORY STATUS:** MCLG: 0.007 mg/L; MCL: 0.007 mg/L; HAL(child): 1 day: 2 mg/L, Longer-term: 1 mg/L; the concentration to keep the cancer risk level 10<sup>-5</sup> is 0.33 µg/L; ambient water quality criterion: 0.033 µg/L at the 10<sup>-6</sup> risk level assuming 70 kg human consuming 2 L water and 6.5 g fish/shellfish per day; **Criterion to protect freshwater aquatic life:** 11,600 µg/L on an acute toxicity basis; 530 µg/L/24 hr avg, concentration not to exceed 1,400 at any time; **Criterion to protect saltwater aquatic life:** 224,000 µg/L on an acute basis, 1700 µg/L as a 24-hour average, not to exceed 3,900 µg/L**PROBABLE FATE: photolysis:** aquatic photodissociation is precluded by volatilization, tropospheric photooxidation precludes stratospheric photodissociation, C-Cl bond can photolyze slowly; **oxidation:** tropospheric photooxidation by hydroxyl radicals is rapid and yields a variety of products; the half-life due to photooxidation is 11 hrs in relatively clean air and <2 hrs in polluted air; in water, photooxidation is unimportant; **hydrolysis:** too slow to be significant; very

slow hydrolysis in the ground water is expected to occur; a half-life of 6-9 months was noted for hydrolysis with minor differences in rate between pH 4.5 and pH 8.5, there is also a suggested hydrolysis half-life of 2 yr @ pH 7 which is markedly different; **volatilization**: rapid volatilization is the main transport process; **sorption**: probably cannot compete with volatilization as a transport process; **evaporation** from water @ 25°C of 1 ppm solution is 50% after 22 min. and 90% after 89 min.; measured half-life for evaporation from 1 ppm aqueous solution at 25 °C, still air, and an average depth of 6.5 cm is 27.2 min.; half-life lost by evaporation when released in water is 1-6 days; half-life for evaporation from a pond, river, or lake is calculated as: 5.9, 1.2, and 4.7 days respectively

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Filtration*, >52, <2; *Sedimentation*, 0, negative removal, *Sedimentation with chemical addition (alum, powder)*, >98, <10

**KEY REFERENCES:** 19,20,21,22,23,24,25,26,27,28,29

### 1,2-trans-DICHLOROETHYLENE (C<sub>2</sub>H<sub>2</sub>Cl<sub>2</sub>, 96.94)

**CAS/DOT IDENTIFICATION #:** 156-60-5/UN 1150

**SYNONYMS:** ethylene,1,2-dichloro, sym-dichloroethylene, acetylenedichloride; Dioform; trans-1,2-dichloroethene

**PHYSICAL PROPERTIES:** colorless liquid; sweet, pleasant odor; MP (-50°C); BP (48°C); DN (1.2565 @ 20°C); SG (1.26); VD (3.34); solubility (600 mg/L @20°C); VS (0.41 cP @20°C); VP (200 mm 14°C); HV (73.7 cal/g @ bp); OT (17 ppm); Log Kow (2.06); H (5.32 x 10<sup>-3</sup> atm·m<sup>3</sup>·mole<sup>-1</sup>)

**CHEMICAL PROPERTIES:** vapor forms explosive mixture with air; incompatible with strong oxidizers; FP (2°C); LFL/UFL (9.7%, 12.8%); AT (460°C)

**BIOLOGICAL PROPERTIES:** Koc: 49; very high mobility in soil; gradually decomposed by air, light, and moisture forming HCl; expected to leach into groundwater if released on soil; can be detected in water by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF: 22; not expected to bioconcentrate in aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES:** under anaerobic conditions, it is formed by the breakdown of trichloroethylene, tetrachloroethylene, and 1,1,2,2-tetrachloroethane; solvent for waxes, resins, and acetylcellulose; a refrigerant; in extraction of rubber; manufacture of pharmaceuticals; artificial pearls; in the extraction of oils and fats from fish and meat

**TOXICITY:** bluegill (*Lepomis machrochirus*) LC<sub>50</sub>: 135,000 µg/L/96-hr in a static unmeasured bioassay

**EXPOSURE ROUTES:** air emissions and wastewater; inhalation of the vapor; ingestion; contact with skin and eyes; urban air, contaminated drinking water

**REGULATORY STATUS:** MCLG: 0.1 mg/L; MCL: 0.1 mg/L; HAL(child): 20 mg/L in one day, 2 mg/L longer term; **Criterion to protect freshwater aquatic life:** 11,600 µg/L

based on acute toxicity; 620 µg/L/24 hr avg., concentration not to exceed 1400 µg/L at any time; **Criterion to protect saltwater aquatic life:** 224,000 µg/L based on acute toxicity, insufficient data to set criterion for human health; the following are standards and guidelines in drinking water set by some states: 16 µg/L (California), 70µg/L (Kansas), 270 µg/L (Maine); 70 (Minnesota), 100 (Wisconsin)

**PROBABLE FATE:** *photolysis:* not important except as photooxidation, C-Cl bond can photolyze slowly; *oxidation:* rapid tropospheric photooxidation by hydroxyl radicals yields many products, probable predominant fate; *hydrolysis:* too slow to be significant; *volatilization:* rapid volatilization is the major transport process, half-life from a model river: 3 hr; *biological processes:* very low potential for bioaccumulation, and biodegradation is probably too slow to be significant; *evaporation* from water @ 25°C of 1 ppm solution: 50% after 24 min. and 90% after 83 min.; evaporation half-life from 1 ppm aqueous solution @ 25°C, still air, and an average depth of 6.5 cm: 24 min.; adsorption to sediment probably not important; considerable dispersal from source areas expected to occur

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, ~20, *Filtration and Sedimentation*, 0, negative removal; *Sedimentation with chemical addition (polymer)*, 0, negative removal; *Sedimentation with chemical addition (alum, polymer)*, 28, 190; *Steam stripping*, 76->99, 34,0000; *Ozonation*, 0, negative removal; best available treatment technologies: granular activated charcoal and packed tower aeration

**KEY REFERENCES:** 11; 21; 22; 23; 24; 25; 29

## 2,4-DICHLOROPHENOL (Cl<sub>2</sub>C<sub>6</sub>H<sub>3</sub>OH, 163)

**CAS/DOT IDENTIFICATION #:** 120-83-2/UN 2020

**SYNONYMS:** DCP, 2,4-DCP

**PHYSICAL PROPERTIES:** colorless, crystalline solid; phenolic odor; slightly soluble in water; dissolves readily in ethanol and benzene; MP (45 °C); BP (210 °C); DN (1.383 g/mL @ 60 °F); SG (1.4 @ 15°C); VP (1 mmHg @ 53 °C); VD (5.62); OT (0.21 ppm); solubility in water (4,500 mg/L @ 20°C); Log Kow (2.75); pKa (7.69 @ 25°C)

**CHEMICAL PROPERTIES:** reacts with benzene sulfonyl chloride to produce miticides; combustible; can react vigorously with oxidizing agents; incompatible with acid chlorides and acid anhydrides; FP (114 °C)

**BIOLOGICAL PROPERTIES:** degradation produces succinic acid; oxidative degradation in natural lake waters is reported; 98% removal (measured as COD removal) at 20°C in activated sludge at a rate of 10 mg COD/g dry inoculum/hr; 75% inhibition of nitrification process in non acclimated activated sludge; decomposition rate in soil suspensions: 9 days for complete disappearance; half-life (aerobic): 4 weeks-6 months; half-life (anaerobic): 16 weeks-24 months; half-life (soil and surface water): 4 weeks-6 months; half-life (ground water): 8 weeks-12 months; can be detected in water by EPA Method 604: methyl chloride extraction followed by gas chromatography with flame ionization or electron capture detection, and EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (in fish at 8 ppm): 34

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of industrial and agricultural products; intermediate in chemical industry; feedstock to manufacture 2,4-dichlorophenoxyacetic acid and its derivatives (germicides, soil sterilants); moth proofing; anti-septics; seed disinfectants; organic synthesis

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 6 mg/L, algae (*Microcystis aeruginosa*): 2 mg/L, green algae (*Scenedesmus quadricauda*): 3.6 mg/L, protozoa (*Entosiphon sulcatum*): 0.5 mg/L; guppy (*Poecilia reticulata*): 24 hr LC<sub>50</sub>: 4.2 ppm @ pH 7.3, goldfish: 24 hr LC<sub>50</sub>: 7.8 ppm, amount found in dead fish at 8 ppm: 268 µg/g

**EXPOSURE ROUTES:** industrial workers while manufacturing or handling

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 2,020 µg/L based on acute toxicity, 365 µg/L based on chronic toxicity, 0.4 µg/L/24 hr avg., concentration not to exceed 100 µg/L any time; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** 0.3 µg/L based on organoleptic limits, 3,090 µg/L based on toxicity data; USSR MAC: 2 µg/L; the following are guidelines in drinking water set by some states: 200 µg/L (Maine), 700 µg/L (Kansas)

**PROBABLE FATE:** **photolysis:** possible, but cannot compete with microbial biodegradation; **oxidation:** any oxidation which occurs is too slow to be important; **hydrolysis:** not an important process, first-order hydrolytic half-life: 3.4 yrs; **volatilization:** not expected to be an important process; **sorption:** sorption will not remove significant amounts; **biological processes:** rapid microbial degradation is the principal fate of 2,4-DCP; **other reactions/interactions:** chlorination of water may produce further chlorination of 2,4-DCP

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Filtration*, 0, negative removal; *Sedimentation*, 33-98, 29; *Activated sludge*, >25->50, <7; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 10

**KEY REFERENCES:** 21; 23; 24; 25; 26; 28

## 1,2-DICHLOROPROPANE(CH<sub>2</sub>CHClCH<sub>2</sub>Cl, 112.99)

**CAS/DOT IDENTIFICATION #:** 78-87-5/UN 1279

**SYNONYMS:** propylene dichloride; alpha,beta-dichloropropane; propylene chloride

**PHYSICAL PROPERTIES:** colorless liquid; chloroform-like odor; slightly soluble in water; miscible with organic solvents; MP (-100.4 °C); BP (96.4 °C); DN (1.159 @ 25 °C%); SG (1.16 @ 20°C); ST (29 dynes/cm); VD (3.9); VP (49.67 mmHg @ 25°C); solubility in water (2700 mg/L @ 20°C); OT (420 mg/m<sup>3</sup>); HV (8428.5 gcal/gmole); critical temperature (304 °C); critical pressure (42.73 atm), Log Kow (1.99); H (2.82 x 10<sup>-3</sup> atm-m<sup>3</sup>-mole<sup>-1</sup>)

**CHEMICAL PROPERTIES:** flammable; sensitive to heat; incompatible with strong oxidizers and strong acids; FP (60 °F); LFL/UFL (3.4%, 14.5%); AT (1035 °F); HC (-7300 Btu/lb)

**BIOLOGICAL PROPERTIES:** T.O.C.: 235 mg/m<sup>3</sup>; Koc: 47 in silt loam; very high mobility in soil; adsorption to soil is insignificant; can be detected in water by EPA Method 601:

inert gas purge followed by gas chromatography with halide specific detection or by EPA Method 624: gas chromatography plus mass spectrometry; aerobic half-life: 167 days - 3.5 yrs; anaerobic half-life: 668 days-14.1 yrs

**BIOACCUMULATION:** Log BCF: <1 in fish; bioconcentration in fish not significant

**ORIGIN/INDUSTRY SOURCES/USES:** rubber processing; chemical intermediate for: perchloroethylene, carbon tetrachloride, chlorinated organic chemicals; livestock; degreasing; fumigant; spotting agent; photographic film; paper coating; solvent: plastic, resins, metal industries, waxes, gums, ethers

**TOXICITY: Fish:** guppy (*Poecilia reticulata*): 7 d LC<sub>50</sub>: 116 ppm; *Lepomis macrochirus*: static bioassay in freshwater @ 23°C, mild aeration applied after 24 hr, best fit 96 hr LC<sub>50</sub>: 320 ppm; *Menidia beryllina*: static bioassay in freshwater @ 23°C, mild aeration applied after 24 hr, best fit 96 hr LC<sub>50</sub>: 240 ppm; **Crustacean:** shrimp: TLm 48 hr: >100 ppm

**EXPOSURE ROUTES:** ambient air; drinking water; groundwater; evaporation from contaminated wastewater; inhalation of vapor

**REGULATORY STATUS:** MCLG: 0 mg/L; MCL: 0.005 mg/L; HAL(child): 10-day:0.09 mg/L; NOEL: 8.8 mg/kg/day; **Criterion to protect freshwater aquatic life:** -23,000 µg/L based on acute toxicity, 5,700 µg/L based on chronic toxicity, 920 µg/L/24 hr avg., concentration not to exceed 2100 µg/L any time; **Criterion to protect saltwater aquatic life:** 10,300 µg/L based on acute toxicity, 3,040 based on chronic toxicity, 400 µg/L/24 hr. avg., concentration not to exceed 910 µg/L any time; no set value for criterion to protect human health because insufficient data; EPA limit in drinking water: 0.005 mg/L; the following are guidelines for drinking water set by some states: 1 µg/L (Arizona, Massachusetts), 6 µg/L (Kansas, Minnesota), 10 µg/L (California, Connecticut)

**PROBABLE FATE: photolysis:** can occur in atmosphere, in air reacts with photochemically generated hydroxyl radicals, half-life: >23 days; **oxidation:** photooxidation in troposphere is probably important; **hydrolysis:** not expected to compete with volatilization, first-order hydrolytic half-life: 15.8 yr; **volatilization:** probable important transport process, if injected to soil, primarily lost by volatilization, volatilization from surface water half-life: 6hr and 10 days for a river and a lake respectively; **biological processes:** compound can be used as a carbon source by several soil bacteria; washed out of air by rain

**TREATABILITY/REMOVABILITY (Process, Removable Range (%), Avg. Achievable Conc. (µg/L)):** *Filtration*, 0, negative removal; *Sedimentation with chemical addition (alum, lime)*, 59, 400; *Activated sludge*, >68->82, <5.4; *Powdered activated carbon adsorption*, 93, 70,000; *Granular activated carbon adsorption*, >64->99, 5.4

**KEY REFERENCES:** 19; 20; 21; 22; 23; 24; 25; 26; 29

### 1,3-DICHLOROPROPYLENE (C<sub>3</sub>H<sub>4</sub>Cl<sub>2</sub>, 110.97)

**CAS/DOT IDENTIFICATION #:** 542-75-6/UN 2047

**SYNONYMS:** 1,3-dichloropropene, 3-chloroallyl chloride, 3-chloropropenyl chloride, telone, vidden, alpha-chloroallyl chloride, gamma-chloroallyl chloride, NCI-C03985, vidden d, DCP, d-D92, 1,3-dichloro-2-propene, dlorlone II

**PHYSICAL PROPERTIES:** clear, colorless liquid; sweet, chloroform-like odor; insoluble in water; soluble in acetone, toluene, and octane; MP (48°C); BP (104°C); DN (1.220 g/ml @ 20°C); SG (1.198); VD (3.80); VP (34-43 mmHg @ 25°C); ST (31.2 dynes/cm @ 24°C); solubility in water (0.1 mg/mL @ 16.5°C);HV (62.8 cal/g); OT (1.0 ppm); Log Kow (1.60); H (3.55 x 10<sup>-3</sup> atm-m<sup>3</sup>-mole<sup>-1</sup>); refractive index (1.4735 @ 22°C)

**CHEMICAL PROPERTIES:** oxidizable; reacts strongly with active metals, Al, Mg, halogens, oxidizers; flammable; HC (3900 cal/g); FP (25°C); LFL/UFL (5.3%, 14.5%); Burning rate (3.4 mm/min)

**BIOLOGICAL PROPERTIES:** slightly persistent in water, half-life: 2-20 days; can be detected in drinking water by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection or EPA Method 624: gas chromatography followed by mass spectrometry; aerobic half-life: 7 days-4 weeks; anaerobic half-life: 28 days-16 weeks; half-life (air): 3.35 days; half-life (soil): 5.5 days-11.3 days; half-life (surface water and ground water): 5.5 days-11.3 days

**BIOACCUMULATION:** concentration found in fish tissues is probably the same as the average concentration in the water the fish were taken.

**ORIGIN/INDUSTRY SOURCES/USES:** soil fumigant; organic synthesis; soil fumigant; nematocide; pesticide, chemical intermediate

**TOXICITY:** algae (*Scenedesmus*): deterioration from 40 mg/L and greater; anthrododa (*Daphnia*): deterioration from 40 mg/L and greater; Protozoa (*Colpoda*): deterioration from 100 mg/L and greater

**EXPOSURE ROUTES:** inhalation is primary route; adsorption through skin and eyes; drinking contaminated water; occupational exposure during manufacture, formulation and application as a soil fumigant; ingestion

**REGULATORY STATUS:** drinking water level on a lifetime basis: 0.11 mg/L; **Criterion to protect freshwater aquatic life:** 6,060 µg/L based on acute toxicity, 244 µg/L based on chronic toxicity, 19 µg/L/24 hr. avg.; concentration not to exceed 11,000 µg/L any time; **Criterion to protect saltwater aquatic life:** 790 µg/L based on acute toxicity, 5.5 µg/L/24 hr. avg., concentration not to exceed 14 µg/L any time; **Criterion to protect human health:** 87.0 µg/L; the following are standards or guidelines in drinking water set by some states: 10 µg/L (Connecticut), 87 µg/L (Arizona and Kansas), 89 µg/L (Vermont)

**PROBABLE FATE:** **photolysis:** direct photolysis in water expected to be slow; **oxidation:** photooxidation in the troposphere is probably the predominant fate process; **hydrolysis:** slow hydrolysis to 3-chloroallyl alcohol occurs, may be important process, first order hydrolytic half-life: 5.5 days-11.3 days; **volatilization:** volatilization to the atmosphere should be a major transport process; **biological processes:** biodegradation is possible; **evaporation** from water @ 25°C of 1 ppm solution is 50% after 31 min., and 90% after 98 min; about 95% ends up in air; the rest ends up in water

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Activated sludge*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), 85, 750

**KEY REFERENCES:** 19; 21; 23; 24; 25; 26; 27; 28

**DI-N-OCTYL PHTHALATE (C<sub>24</sub>H<sub>38</sub>O<sub>4</sub>, 391.0)****CAS/DOT IDENTIFICATION #:** 117-84-0/UN not available

**SYNONYMS:** DNOP, benzenedicarboxylic acid di-n-octyl ester, n-dioctyl phthalate, octyl phthalate, bis(n-octyl) phthalate, vinicizer 85, dioctyl o-benzenedicarboxylate, celluflex dop

**PHYSICAL PROPERTIES:** light colored oily liquid; insoluble in water; MP (-25°C); BP (230°C @ 5 mmHg); DN (0.978 g/mL); SG (0.978); VP (<0.2 torr @ 150°C); solubility in water (3 mg/L); Log Kow (~9.2)

**CHEMICAL PROPERTIES:** combustible; FP (219°F); AT (390.6°C); LEL (0.3%)

**BIOLOGICAL PROPERTIES:** slowly biodegrades with acclimation; half-life removal from the aqueous phase: 5 days in an ecosystem study; not expected to readily leach into ground water; aerobic degradation in freshwater hydrosol: 50% after 14 days incubation; slightly persistent in water, with a half-life of between 2 to 20 days; if emitted to the atmosphere as an aerosol, it will be subject to gravitational settling; soil, surface water, and aerobic half-life: 7 days-4 weeks; ground water half-life: 14 days-1 yr; anaerobic half-life: 6 months-1 yr; can be detected in water by EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** bioconcentrates in algae and other aquatic organisms; bioconcentration is important in species where little or no metabolism occurs; the concentration found in fish tissues is expected to be considerably higher than the average concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** plasticizer in plastic products manufacturing and rubber materials; plasticizer for cellulose ester resins, polystyrene resins, and vinyl resins; dye carrier used for film, cables, and adhesives

**TOXICITY:** moderate acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** industrial discharges; municipal waste water treatment discharges; spills; occupational exposure; plastic containers for food

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** USSR-UNEP/IRPTC MAC: 1.0 mg/L in water bodies used for domestic purposes

**PROBABLE FATE:** *photolysis:* no direct photolysis, indirect photolysis is too slow to be important, photooxidation half-life in air: 4.5 hrs-1.9 days, if emitted to atmosphere, will be subject to photodegradation by hydroxyl radicals with a half-life of 14 hr; *oxidation:* not an important process; *hydrolysis:* hydrolysis only in surface waters but too slow to be important, first-order hydrolytic half-life: 107 yrs; *volatilization:* not expected to be an important transport process; *sorption:* adsorption onto solids and particles and complexation with organics are important transport processes, will adsorb strongly to sediment and particulate matter; *biological processes:* bioaccumulation by many organisms, biodegradation and metabolization are all important fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gas flotation with chemical addition (calcium chloride, polymer)*, 78, 33; *Gas flotation with chemical addition (polymer)*, 61, 11; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, >73->96, <1.5; *Sedimentation*, >49->99, <35;

*Sedimentation with chemical addition (alum, polymer)*, 92, 5; *Activated sludge*, 50->99, 2500; *Activated sludge* (based on synthetic wastewater), 94, 300; *Granular activated carbon adsorption*, 76-96, 110

**KEY REFERENCES:** 21; 23; 26; 27; 28; 30

### **DIELDRIN (C<sub>12</sub>H<sub>8</sub>Cl<sub>6</sub>O, 381)**

**CAS/DOT IDENTIFICATION #:** 60-57-1/UN NA2761

**SYNONYMS:** 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-dimethanonaphthalene, octalox®, Heod

**PHYSICAL PROPERTIES:** colorless to light tan solid; mild chemical odor; MP (175-176°C); BP (decomposes); DN (1.75 g/cm<sup>3</sup> @ 25°C); SG (1.75); VP (1.78x10<sup>-7</sup> mmHg @ 20°C); VD (13.2); solubility in water (186 µg/L @ 25°C); OT (0.04 mg/L in water); Log Kow (); H (5.8x10<sup>-5</sup> atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** incompatible with strong oxidizers, active metals like sodium, strong acids, and phenols; nonflammable

**BIOLOGICAL PROPERTIES:** extremely persistent in water; slowly photorearranges to photodieldrin (water half-life: 4 months); will stay in soil for >7 yrs if released to soil; not expected to leach into groundwater; can be carried long distances; 95% disappearance from soil took 12.8 yrs; 75-100% disappearance from soils: 3-25 yrs; soil, surface water, and aerobic half-life: 175 days-3 yrs; anaerobic half-life: 1-7 days; ground water half-life: 1 day-6 yrs; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with electron capture or halogen specific detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** retention in animal fats, plant waxes, and other organic matter; aggressive accumulation in the food chain because of its high affinity for fat and its fat solubility which results in a concentrated organism which could exceed the lethal limit for a consumer; palecypod (*Crassostrea virginica*): BCF(exposure 0.5 µg/L, 168 hr): 2880; bioaccumulation (exposure 1-100 µg/L, 43 days): 5100-5500; 5 aquatic molluscs: BCF: 700-1800; oyster (*Crassostrea virginica*): BCF (after 168 hr exposure): 2070-2880; trout: BCF: 3300

**ORIGIN/INDUSTRY SOURCES/USES:** manmade compound; belongs to the group of cyclodiene insecticides; control of corn pests (former use); stereo-isomer of endrin; wool processing industry

**TOXICITY:** Fish: *Pimephales promelas*: 96 hr LC<sub>50</sub>: 16 µg/L; *Lepomis macrochirus*: 96 hr LC<sub>50</sub>: 8 µg/L; *Salmo gairdneri*: 96 hr LC<sub>50</sub>: 10 µg/L; striped killfish (*Fundulus majalis*): 96 hr static lab bioassay: LC<sub>50</sub>: 4 ppb (100%); American eel (*Anguilla rostrata*): 96 hr static lab bioassay: LC<sub>50</sub>: 0.9 ppb (100%); bluehead (*Thalassoma bifasciatum*): 96 hr static lab bioassay: LC<sub>50</sub>: 6 ppb (100%); blugill: 96 hr LC<sub>50</sub>: 0.008 ppm; rainbow trout: 96 hr LC<sub>50</sub>: 0.019 ppm; minnow: 24 hr LC<sub>50</sub>: 24 ppb; many more (found in references below)

**EXPOSURE ROUTES:** inhalation; skin adsorption; ingestion; eye and skin contact; mostly from food

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** 0.0019 µg/L/24 hr avg., not to exceed 2.5 µg/L any time; **Criterion to protect saltwater aquatic life:** 0.0019 µg/L/24 hr avg., not to exceed 0.71 µg/L any time; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 0.71 ng/L; Mexico MAC: 0.017 mg/L in water used for drinking water supply, 0.003 mg/L in estuaries, 0.03 µg/L in estuaries; WHO limit in drinking water: 0.03 µg/L; the following are guidelines in drinking water set by some states: 0.01 µg/L (Minnesota); 0.019 µg/L (Kansas); 0.05 µg/L (California); 1.0 µg/L (Illinois)

**PROBABLE FATE: photolysis:** direct photolysis may be important; **oxidation:** probably not important, photooxidation by u.v. light in aqueous medium @ 90-95°C, formation of CO<sub>2</sub>: 25% took 2.9 hr, 50% took 4.8 hr, 75% took 12.5 hr, photooxidation half-life in air: 4 hrs-1.7 days; **hydrolysis:** hydrolysis of epoxide, too slow to be important, first-order hydrolytic half-life: 10.5 yrs; **volatilization:** volatilization is an important process, volatilization @ 25°C from soils in lab: sandy loam: 8.9% after 60 days, sand: 34.2% after 60 days, calculated half-life in water based on an evaporation rate of  $5.33 \times 10^{-5}$  m/hr: 12,940 hr; **sorption:** probably an important process, will adsorb strongly to sediments once it reaches surface water; **biological processes:** moderate bioaccumulation

**TREATABILITY/REMOVABILITY (Process, Removable Range (%), Avg. Achievable Conc. (µg/L)):** *Gravity oil separation*, not available, 3; *Activated sludge*, 0, negative removal; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 0.5

**KEY REFERENCES:** 21; 23; 25; 26; 28; 30

## DIETHYLPHTHALATE (C<sub>12</sub>H<sub>14</sub>O<sub>4</sub>, 222.2)

**CAS/DOT IDENTIFICATION #:** 84-66-2/UN not available

**SYNONYMS:** DEP, ethylphthalate

**PHYSICAL PROPERTIES:** water-white liquid; odorless; slightly soluble in water; MP (-40.5°C); BP (298°C); SG (1.120); VP (0.05 torr @ 70°C); VD (7.6); solubility in water (1000 mg/L @ 32°C); Log Kow (3.22)

**CHEMICAL PROPERTIES:** FP (160°C)

**BIOLOGICAL PROPERTIES:** expected to leach and volatilize; slightly persistent in water, half-life: 2-20 days; if released to soil, expected to undergo aerobic degradation, if released to water, expected to biodegrade; soil, surface water, and aerobic half-lives: 3 days-8 weeks; ground water half-life: 6 days-16 weeks; anaerobic half-life: 4-32 weeks; anaerobic degradation is expected to be very slow or not occurring at all; % degraded under anaerobic continuous flow conditions: 20-98%; can be detected in water by EPA Method 606: methylene chloride extraction followed by gas chromatography with flame ionization or electron detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** bioaccumulation in aquatic organisms should not be significant; the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** solvent for cellulose esters; pesticidal sprays; fixative and solvent in perfumes; alcohol denaturant; plasticizer in solid rocket propellants; organic chemical industry; wetting agent; mosquito repellent; food packaging application

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): >400 mg/L, algae (*Microcystis aeruginosa*): 15 mg/L, green algae (*Scenedesmus quadricauda*): 10 mg/L, protozoa (*Entosiphon sulcatum*): 19 mg/L; protozoa (*Uronema parduczi Chatton-L-woff*): 48 mg/L; marine dinoflagellate (*Gymnodium breve*): TLm 24 hr: 23.5 ppm, TLm 96 hr: 33 ppm, EC<sub>50</sub>: 3.0-6.1 ppm

**EXPOSURE ROUTES:** air emissions; aqueous effluent and solid waste products from manufacturing and processing plants; incineration of DEP containing plastics; ingestion of food; inhalation and dermal exposure; occupational exposure

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** 350 mg/L; Kansas guideline for drinking water: 350 mg/L

**PROBABLE FATE:** **photolysis:** no direct photolysis, indirect photolysis is too slow to be important, the vapor is expected to react with photochemically produced hydroxyl radicals, with an estimated half-life of 22.2 hrs; **oxidation:** not an important process, photooxidation half-life in water: 2.4-12.2 yrs, photooxidation half-life in air: 21 hrs-8.8 days; **hydrolysis:** expected to be too slow to be important under natural conditions, first-order hydrolytic half-life: 8.8 yrs; **volatilization:** not considered as important as sorption, however, there is very little data, volatilizes from dry soil surfaces, volatilization may be important in shallow rivers; **sorption:** adsorption onto solids and particles and complexation with humic material (fulvic acid) are the principal transport mechanisms; **biological processes:** bioaccumulation, biodegradation, and biotransformation by many organisms (including humans) are very significant fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 12; *Gas flotation*, >17, not detected; *Filtration*, 37->99, 2000; *Sedimentation*, 33->99, 24; *Sedimentation with chemical addition*, >99, <10; *Sedimentation with chemical addition*, >98, <0.03; *Aerated lagoons*, 0, negative removal; *Trickling filters*, 0, negative removal; *Activated sludge*, 58->99, 6; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Granular activated carbon adsorption*, 0, negative removal; *Powdered activated carbon adsorption* (based on synthetic wastewater), 95, 860; physical removal by *particulate settling* and *washout* in precipitation is expected to occur

**KEY REFERENCES:** 21; 23; 25; 26; 27; 30

## 2,4-DIMETHYLPHENOL (C<sub>8</sub>H<sub>10</sub>O, 122.16)

**CAS/DOT IDENTIFICATION #:** 105-67-9/UN 2261

**SYNONYMS:** 2,4-xylenol, 1-hydroxy-2,4-dimethylbenzene, 4,6-dimethylphenol, 4-hydroxy-1,3-dimethylbenzene, m-xylenol, phenol, 2,4-dimethyl

**PHYSICAL PROPERTIES:** colorless needles; soluble in alcohol and ether; very soluble in benzene and chloroform; MP (26 °C); BP (211.5 °C); DN (0.9650 @ 20°C); SG (1.036); VP (0.0621 torr @ 20°C); OT (0.001 mg/m<sup>3</sup> recognition in air); taste (0.5 mg/L); solubility in water (17,000 mg/L @ 160 °C); HV (13,120.2 g-cal/g-mol); Log Kow (2.30); H (6.3 x 10<sup>-3</sup> atm<sup>3</sup>/mole @ 8°C); pKa (10.58 @ 25 °C)

**CHEMICAL PROPERTIES:** can be oxidized to form pseudoquinone; FP (110 °C)

**BIOLOGICAL PROPERTIES:** BOD<sub>5</sub> @ 30°C: @ 15 mg/L: nil (seed water from phenol-degradation plant); inhibition of degradation of glucose by *Pseudomonas fluorescens*: 40 mg/L; inhibition of degradation of glucose by *E. coli*: 500 mg/L; anaerobic degradation of phenolic compounds to methane and carbon dioxide in sewage sludge digestion; 95% removed @ 20°C in activated sludge at a rate of 28 mg COD/g dry inoculum/hr; degradation half-life: hours to days; degrades rapidly at night by reaction with nitrate radicals; anaerobic half-life: 4-28 days; aerobic half-life: 1-7 days; can be detected in water by EPA Method 604: methyl chloride extraction followed by gas chromatography with flame ionization or electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** Log BCF (bluegills: *Lepomis macrochirus*): 1.18; Log BCF (species of fish): 1.8-2.18; has the possibility to bioaccumulate, but not significantly; the concentration found in fish tissues is probably less than the average concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** from coal tar fractionation and coal processing; intermediate in manufacturing of phenolic antioxidants; pharmaceuticals; plastics; resins; disinfectants; solvents; insecticides; fungicides; rubber chemicals; polyphenylene oxide; dye-stuffs; cresylic acid constituent; wetting agent; additive of lubricants and gasoline

**TOXICITY:** bacteria (*E. coli*): LD<sub>50</sub>: 500 mg/L; algae (*Scenedesmus*): LD<sub>50</sub>: 40 mg/L; arthropoda (*Daphnia*): LD<sub>50</sub>: 24 mg/L; fish (crucian carp, trench, trout embryo): TLm (24 hr): 30 mg/L, 13 mg/L, 28 mg/L

**EXPOSURE ROUTES:** dermal contact with chemicals containing phenolic mixtures; inhalation; workers involved in fractionation and distillation of petroleum or coal; exposure to commercial degreasing agents containing cresol; cigarette and marijuana smokers; those exposed to cigarette smoke inhale µg quantities

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 2,120 µg/L based on acute toxicity, 38 µg/L/24-hr avg., concentration not to exceed 86 µg/L any time; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** 400 µg/L by EPA on an organoleptic basis; the following are guidelines set by some states: 400 µg/L (Kansas and California)

**PROBABLE FATE:** **photolysis:** photooxidation definitely occurs, photooxidation half-life in water: 3.2-160 days; photooxidation half-life in air: 1.19-11.9 hrs; **oxidation:** metal-catalyzed oxidation occurs in aerated surface waters, oxidation by peroxy radicals is important, photochemically produced hydroxyl radicals degrades compound in daylight hours, half-life: 8 hrs; **hydrolysis:** not an important process; **volatilization:** not an important process; **sorption:** slight potential for adsorption onto organic materials, adsorption to sediment will be moderate; **biological processes:** biodegradation can occur; **other reactions/interactions:** chlorine present in water could chlorinate the compound; can be washed out by rain

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 210; *Gas flotation with chemical addition (calcium chloride, polymer)*, >99, <0.1; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Filtration*, 0, negative removal; *Sedimentation*, 18->55, <15; *Sedimentation with chemical addition (lime, polymer)*, 76, <10; *Activated sludge*, 32-95, <9; *Granular activated carbon adsorption*, >89, <0.1; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 130

**KEY REFERENCES:** 11; 21; 22; 23; 24; 25; 26; 27

**4,6-DINTRO-o-CRESOL (CH<sub>3</sub>C<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>2</sub>OH, 198.13)**

CAS/DOT IDENTIFICATION #: 534-52-1/UN 1598

**SYNONYMS:** antinonin, arborol, detal, dillex, dinitro-o-cresol (3,5), DNOC, effusan, el-getol, extrar, nitro-fan, selinon, sinox, winterwash, 2-methyl-4,6-dinitrophenol, 3,5-dinitro-2-hydroxytoluene

**PHYSICAL PROPERTIES:** yellow prisms; solid; sodium salt is a red powder; sparingly soluble in water; soluble in alkaline aqueous solutions; MP (85.8°C); BP (312 °C); VD (6.84); VP (1.05x10<sup>-4</sup> @ 25°C); OT (1.3 mg/L), Log Kow (2.564); H (1.4x10<sup>-6</sup> atm-m<sup>3</sup>/mole); pKa (4.4)

**CHEMICAL PROPERTIES:** stable during transport; incompatible with strong oxidizers; will not polymerize; HC (-3920 cal/g); AT (435°C)

**BIOLOGICAL PROPERTIES:** Koc: 255-590; medium to low soil mobility; 1% removal after 48 hr incubation for initial feed of 207 mg/L; inhibition of degradation of glucose by *Pseudomonas fluorescens*: 30 mg/L; inhibition of degradation of glucose by *E. coli*: 100 mg/L; when released to soil, disappearance within a few weeks to 2 months; aerobic half-life: 7-21 days; anaerobic half-life: 2.8-7.1 days; ground water half-life: 2.8-42 days; surface water half-life: 3.2-21 days; can be detected in water by EPA Method 604: methylene chloride extraction followed by gas chromatography with flame ionization or electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (from regression equations): 24, 37, 40 and 52; may not bioaccumulate because of its toxicity; concentration found in fish tissues is expected to be somewhat higher than the average concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** dormant oxidical spray for fruit trees; herbicide; defoliant; dyestuffs; weight reducing agent (previously); free-radical polymerization inhibitor; toxic to eggs of certain insects; thinning blossoms of trees; to kill locusts; fungicide; preharvest desiccation of potatoes

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 16 mg/L, algae (*Microcystis aeruginosa*): 0.15 mg/L, green algae (*Scenedesmus quadricauda*): 13 mg/L, protozoa (*Entosiphon sulcatum*): 5.4 mg/L, protozoa (*Uronema parvum*; *Chatton-L-woff*): 0.012 mg/L; bacteria (*E. coli*): toxic: 100 mg/L; algae (*Scenedesmus*): toxic: 36 mg/L; arthropods (*Daphnia*): toxic: 8 mg/L; Fish (*Salmo salar*, juvenile): lethal threshold, S: 200 µg/L; 24hr LC50 (Water flea): 6.6 mg/L; LC50 (Fish): 1.5-4.0 mg/L in distilled water @ 23°C

**EXPOSURE ROUTES:** inhalation or dermal contact; manufacture, formulation, application of pesticide; pesticide leaching or runoff; percutaneous adsorption; wastewater effluents

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** no data available; **Criterion to protect saltwater aquatic life:** no data available; **Criterion to protect human health:** 13.4 µg/L; USSR MAC in water bodies used for domestic purposes: 0.05 mg/L and in water bodies used for fishing purposes: 0.002 mg/L

**PROBABLE FATE:** **photolysis:** gradual photooxidation expected to occur, main route of degradation in an aquatic environment, photooxidation half-life in water: 3.2-160 days, photooxidation half-life in air: 12.9-129 days, half-life for photooxidation by peroxy radicals: 58 days; **oxidation:** hydroxyl radicals may displace nitro groups, may react with photochemically pro-

duced hydroxyl radicals in vapor phase with a half-life of 77 days; **hydrolysis**: hydrolysis may occur after adsorption by clay minerals; **volatilization**: not an important process; **sorption**: adsorption by clay should be an important transport process; **biological processes**: will not bioaccumulate because of toxicity; biodegradation occurs in soil and possibly in water

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Sedimentation*, 48->95, 460; *Sedimentation with chemical addition*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), 28, 2100, *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 50

**KEY REFERENCES**: 11; 14; 19; 21; 23; 25; 26; 27

## 2,4-DINITROPHENOL ( $\text{C}_6\text{H}_4\text{N}_2\text{O}_5$ , 184.12)

**CAS/DOT IDENTIFICATION #**: 51-28-5/ UN 1320

**SYNONYMS**: aldifen, chemox Pe, alpha-dinitrophenol, 2,4-DNP, 1-hydroxy-2,4-dinitrobenzene, solfo black B, tertosulphur PBR

**PHYSICAL PROPERTIES**: yellow crystals; slightly soluble in water; volatile with steam; very soluble in benzene; MP ( $112^\circ\text{C}$ ); BP (sublimes); DN (1.683 @  $24^\circ\text{C}$ ), VD (6.35); VP ( $1.42 \times 10^{-7}$  mmHg @  $25^\circ\text{C}$ ); solubility in water (5,600 mg/L @  $18^\circ\text{C}$ ); Log Kow (1.91); H ( $8 \times 10^{-10}$  atm-m<sup>3</sup>/mole); pKa (3.94)

**CHEMICAL PROPERTIES**: sublimes when heated; forms explosive salts with alkalis and ammonia

**BIOLOGICAL PROPERTIES**: 85% removal at  $20^\circ\text{C}$  in activated sludge at a rate of 6.0 mg CPD/g dry inoculum/hr; inhibition of degradation of glucose by *Pseudomonas fluorescens*: 3 mg/L; inhibition of degradation of glucose by *E. coli*: >100 mg/L; ~50% inhibition of  $\text{NH}_3$  and  $\text{NO}_2$  oxidation @ 37 mg/L; very mobile if released to soil; aerobic half-life: 2.25-8.77 months; anaerobic half-life: 2.8-7.1 days; ground water half-life: 2.8 days-17.5 months; surface water half-life: 3.2-160 days; can be detected in water by EPA Method 604: methyl chloride extraction followed by gas chromatography with flame ionization or electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION**: BCF: <10 using regression equations; not expected to bioaccumulate in aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES**: intermediate in manufacture of wood preservatives, dyes, pesticides, fungicides, miticides photographic developers, explosives; an indicator for the detection of potassium and ammonium salts

**TOXICITY**: Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 115 mg/L, algae (*Microcystis aeruginosa*): 33 mg/L; protozoa (*Entosiphon sulcatum*): 20 mg/L; bacteria (*E. coli*): toxic: 100 mg/L; algae (*Scenedesmus*): toxic: 40 mg/L; Arthropods (*Daphnia*): toxic: 6 mg/L; Fish (*Salmo salar*, juvenile): lethal threshold, S: 700  $\mu\text{g/L}$

**EXPOSURE ROUTES**: primarily from pesticide runoff to water; readily adsorbed through intact skin; vapors adsorbed through respiratory tract; automobile exhaust gas

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 230 µg/L based on acute toxicity, 79 µg/L/24 hr avg., concentration not to exceed 180 µg/L any time; **Criterion to protect saltwater aquatic life:** 4850 µg/L based on acute toxicity, 37 µg/L/24 hr avg., concentration not to exceed 84 µg/L any time; **Criterion to protect human health:** 68.6-70 µg/L; USSR limit: 30 µg/L; the following are guidelines in drinking water set by some states: 31 µg/L (Kansas), 100 µg/L (Maine)

**PROBABLE FATE:** **photolysis:** degradation by slow photolysis may be principal fate; may undergo direct photolysis due to adsorption of UV light wavelengths >290 nm; **oxidation:** oxidation by hydroxy radicals may occur, photooxidation half-life in water: 3.2-160 days, photooxidation half-life in air: 4.6-46.4 days; **hydrolysis:** slight possibility for hydrolysis after adsorption by clay minerals; **volatilization:** not an important process; **sorption:** slight potential for sorption by clay minerals, if released to water, insignificant adsorption on suspended solids or sediments is expected; **biological processes:** no bioaccumulation, uncertain amount of biodegradation under natural conditions; may react with photochemically produced hydroxyl radicals, vapor phase half-life: 14 hr

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), 100, <50; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 40

**KEY REFERENCES:** 19; 21; 22; 23; 24; 25; 26

## 2,4-DINITROTOLUENE (C<sub>7</sub>H<sub>6</sub>N<sub>2</sub>O<sub>4</sub>, 182.13)

**CAS/DOT IDENTIFICATION #:** 121-14-2/UN 1600 (liquid), UN 2038 (solid)

**SYNONYMS:** 1-methyl-2,4-dinitrobenzene, benzene, 2-methyl-1,3-dinitro-, dichloro-4-hydroxybenzene(1,3-), dintro-toluene(2,4-), dinitrotoluene(2,6-), DNT(2,4-); dinitrotoluol

**PHYSICAL PROPERTIES:** yellow needles, sharp crystals; soluble in alcohol and ether; slight odor; MP (66-70 °C); BP (300 °C with slight decomposition); SG (1.521 @ 15°C); VD (6.27); VP (0.0051 mmHg @ 20°C); solubility (270 mg/L @ 22°C); Log Kow (2.0)

**CHEMICAL PROPERTIES:** combustible when exposed to heat or flame; reacts with oxidizing agents, reducing agents, and strong bases; ignites on contact with sodium oxide; decomposition temperature (250 °C); FP (207 °C); AT (420 °C)

**BIOLOGICAL PROPERTIES:** Koc: 282; slightly mobile in soil; slightly persistent in water; may degrade in aerobic and anaerobic zones of soil; anaerobic biodegradation to the amine is expected to be rapid, aerobic half-life: 4 weeks-6 months; anaerobic half-life: 2-10 days; ground water half-life: 2 days-12 months; can be detected in water by EPA Method 609: methylene chloride extraction followed by exchange to toluene and gas chromatography with flame ionization detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** will not bioconcentrate significantly in water; will have a slight tendency to partition to suspended and sediment organic matter; BCF: 13, 58, 2000 for *Daphnia Magna*, *Lumbriculus variegatus*, and the algae, *Selanastrum capricornutum* exposed to 1 mg/L for 4 days; BCF (bluegill sunfish): 78 in viscera, 4 in muscle, 11-103 in various tissues in 14 days; the concentration found in fish tissues is expected to be somewhat higher than the average concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** intermediate for polyurethanes, explosives, dyes, smokeless gunpowders, toluidines, organic synthesis; manufacture of 2,4-diaminotoluene; propellant additive; gelatinizing and waterproofing agent

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 57 mg/L, algae (*Microcystis aeruginosa*): 0.13 mg/L, green algae (*Scenedesmus quadricauda*): 2.7 mg/L, protozoa (*Entosiphon sulcatum*): 0.98 mg/L, protozoa (*Uronema parduczi Chatton-L-woff*): 0.55 mg/L

**EXPOSURE ROUTES:** inhalation; dermal contact by workers; ingestions and subcutaneous routes; adsorbed by skin; contaminated aquatic organisms; industrial charges

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 330 µg/L based on acute toxicity, 230 µg/L based on chronic toxicity, 620 µg/L/24 hr avg., concentration not to exceed 1400 µg/L any time; **Criterion to protect saltwater aquatic life:** 590 µg/L based on acute toxicity; **Criterion to protect human health:** preferably 0; concentration calculated to keep the lifetime cancer risk level below  $10^{-5}$  is 1.1 µg/L; the following are guidelines in drinking water set by some states: 1.1 µg/L (Kansas and Minnesota)

**PROBABLE FATE:** **photolysis:** intramolecular photolysis possible important fate, aqueous photolytic half-life: 23-72 hrs, atmospheric photolytic half-life: 23-72 hrs, photolytic half-lives in river, bay, and pond waters: 2.7, 9.6, 3.7 hr respectively; **oxidation:** oxidation could follow adsorption onto clay particles, photooxidation half-life in water: 3-33 hrs, photooxidation half-life in air: 11.8-118 days; **hydrolysis:** not an important process; **volatilization:** too slow, therefore not an important process; **sorption:** expected to be strongly adsorbed by humus and clay; **biological processes:** some bioaccumulation possible, biodegradation very slow

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Sedimentation*, 80, 10; *Aerated lagoons*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), 77, 1650; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 90

**KEY REFERENCES:** 19; 21; 22; 23; 24; 25; 26; 27

## 2,6-DINITROTOLUENE (C<sub>7</sub>H<sub>6</sub>N<sub>2</sub>O<sub>4</sub>, 182.1)

**CAS/DOT IDENTIFICATION #:** 606-20-2/UN 2038

**SYNONYMS:** dinitrotoluol, 2,6-DNT, benzene, 2-methyl-1,3-dinitro, 2-methyl-1,3-dinitrobenzene, 1,3-Dinitro 2-methyl benzene

**PHYSICAL PROPERTIES:** rhombic needles; yellow to red solid; slight odor; soluble in alcohol and benzene; MP (65°C); BP (285°C); DN (1.2833 @ 11°C); VP ( $3.5 \times 10^{-4}$  mmHg @ 20°C); VD (6.28); OT (0.1 ppm in water); Log Kow (2.05); H ( $2.17 \times 10^{-7}$  atm·m<sup>3</sup>/mole); Refractive index (1.479)

**CHEMICAL PROPERTIES:** relatively stable; may be an explosion hazard when involved in fire; decomposition emits nitrate fumes; incompatible with strong oxidizers; incompatible with caustics and metals such as tin and zinc; may react with reducing agents; will attack some forms of plastics, rubber and coatings; HC (-8099 Btu/lb); FP (206.7°C)

**BIOLOGICAL PROPERTIES:** slightly mobile if released to soil; slight tendency to sorb to sediments, suspended solids, and biota if released to soil; biodegradation data are inconsistent; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 2-13 days; ground water half-life: 2 days-12 months

**BIOACCUMULATION:** BCF (algal biomass in a model waste stabilization pond): 5225; BCF (using regression equations): 12; Koc: 204

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of explosives like TNT; organic chemicals; urethane polymers; flexible and rigid foams; surface coatings; dyes; organic synthesis; chemical intermediate for toluene-2,6-diamine; gelatinizing; waterproofing agent

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 26 mg/L, green algae (*Scenedesmus quadricauda*): 12 mg/L, protozoa (*Entosiphon sulcatum*): 11 mg/L, protozoa (*Uronema parduczi Chatton-L-woff*): 23 mg/L

**EXPOSURE ROUTES:** drinking water; raw wastewater from textile plants; wastewater from 2,4,6-trinitotoluene production; saltwater

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** not available; **Criterion to protect saltwater aquatic life:** not available; **Criterion to protect human health:** not available

**PROBABLE FATE:** **photolysis:** intramolecular photolysis is possibly important, atmospheric and aqueous photolytic half-life: 17-25 hrs; **oxidation:** photooxidation can occur, photooxidation half-life in water: 2-17 hrs, photooxidation half-life in air: 11.8-118 days, reaction with photochemically produced hydroxyl radicals has a half-life of 8 hr; **hydrolysis:** not an important process; **volatilization:** not expected to be an important transport process, relatively slow; **sorption:** expected to be strongly sorbed by humus and clay; **biological processes:** no data on bioaccumulation, biodegradation very slow

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Sedimentation*, 80, 10; *Sedimentation with chemical addition (lime)*, >79, <10; *Aerated lagoons*, 83, 2; *Activated sludge* (based on synthetic wastewater), 82, 900; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 140

**KEY REFERENCES:** 11; 22; 23; 24; 25; 26; 28

## DIMETHYL PHTHALATE (C<sub>10</sub>H<sub>10</sub>O<sub>4</sub>, 194.20)

**CAS/DOT IDENTIFICATION #:** 131-11-3/UN not available

**SYNONYMS:** Avolin, 1,2-Benzenedicarboxylic acid, Dimethyl ester, Dimethyl-1,2-benzenedicarboxylate, Dimethyl benzeneorthodicarboxylate, DMP, ENT 262, Fermine, Methyl phthalate, Mipax, NTM, Palatinol M, Phthalic acid methyl ester, Phthalsaeuredimethylester (german), Solvanom, Solvarone

**PHYSICAL PROPERTIES:** colorless, oily liquid; slightly sweet odor; miscible with alcohol and ether; insoluble in water and paraffinic hydrocarbons; slightly soluble in mineral oil; MP (0°C); BP (282.4°C); SG (1.190); VP ( $4.19 \times 10^{-3}$  mmHg @ 20°C); VD (6.69); VS (17.2 cP @ 25°C); solubility in water (4300 mg/L @ 32°C); Log Kow (1.56); H ( $1.1 \times 10^{-7}$  atm-m<sup>3</sup>/mole); refractive index (1.5150 @ 20°C)

**CHEMICAL PROPERTIES:** combustible; incompatible with oxidizing agents and acids; HC (119.7 kg-cal/mole); FP (149°C); AT (555°C); LEL/UEL (0.94%, 8.03%)

**BIOLOGICAL PROPERTIES:** Koc: 160 and 44; low adsorption to sediment; slightly persistent in water, half-life: 2-20 days; half-lives in river water: 8-11 days and 0.2 days; 100% removal reported from wastewater treatment plants resulting from biodegradation; soil, surface water, and aerobic half-lives: 1-7 days; anaerobic half-life: 4 days; ground water half-life: 2-14 days; % removal under aerobic conditions: 96%; can be detected in water by EPA Method 606: methylene chloride extraction followed by gas chromatography with flame ionization or electron detection, or EPA Method 626: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** not expected to bioconcentrate in fish; BCF (brown shrimp, sheepshead minnows): 4.7, 5.4 after 24 hr; BCF (bluegill sunfish): 57 which may be too high since only C-14 was used and metabolites may be included with the parent compound; the concentration found in fish tissues is expected to be somewhat higher than the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** solid rocket propellants; lacquers; plastics; resins; safety glasses; rubber coating agents; molding powders; insect repellents; pesticides; solvent and plasticizer for cellulose; acetate and cellulose acetate-butyrate compositions

**TOXICITY:** marine dinoflagellate (*Gymnodium breve*): TL<sub>m</sub> 96 hr: 125-185 ppm, EC<sub>50</sub>: 54-96 ppm; larvae of grass shrimp (*Palaemonetes pugio Holthius*): LC<sub>50</sub> 8 days: 100 ppm, no significant increase in mortality at 1 ppm after 26 days

**EXPOSURE ROUTES:** food; use of hemodialysis tubing; polyvinylchloride bags containing intravenous solutions; drinking water; factories that manufacture or use dimethyl phthalate; inhalation; ingestion; eye and skin contact; industrial water; use of mosquito repellent

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** 313 mg/L; Kansas guideline for drinking water: 313 mg/L

**PROBABLE FATE:** **photolysis:** no direct photolysis, half-life from surface waters: 3500 hr, indirect photolysis is too slow to be important, photodegradation by hydroxyl radicals will occur with a half-life of 23.8 hrs; **oxidation:** not an important process, photooxidation half-life in air: 4.7 days-46.6 days; **hydrolysis:** too slow to be important under natural conditions, first-order hydrolytic half-life: 1163 days; **volatilization:** possible, but not important; **sorption:** sorption onto particles and biota and complexation with humic substances principal transport mechanism, little adsorption to soil or sediment is expected to occur; **biological processes:** bioaccumulation, biodegradation, and biotransformation by many organisms (including humans) are very significant fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Filtration*, >98, <0.03; *Sedimentation*, 49->99, 42; *Aerated lagoons*, 25, 6; *Activated sludge*, 58->99, 19; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon* adsorption (based on synthetic wastewater), 99, 100; *Reverse osmosis*, 30-41, 110; if emitted into the atmosphere, subject to *rainout* and *gravitational settling*

**KEY REFERENCES:** 19; 21; 22; 23; 25; 26; 27; 28; 30

**1,2-DIPHENYLHYDRAZINE (C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>, 184.26)**

**CAS/DOT IDENTIFICATION #:** 122-66-7/UN not available

**SYNONYMS:** N,N-bianiline, N,N'-diphenylhydrazine, hydrazobenzene, hydrozodibenzene, DPH; (sym)-diphenylhydrazine

**PHYSICAL PROPERTIES:** orange-yellow, crystalline powder; slightly soluble in water; insoluble in acetylene; slightly soluble in benzene; MP (126-127°C); BP (decomposes, ~220°C); DN (1.158 g/mL @ 16°C); SG (1.580); solubility in water (221 mg/L); Log Kow (3.03), Log P<sub>oc</sub> (2.94)

**CHEMICAL PROPERTIES:** nonflammable; mild reducing agent; incompatible with strong oxidizers, strong acids, acid chlorides, and acid anhydrides; reaction with acid yields benzidine, diphenylamine, o-benzidine, and o-semidine; in the stomach, can be converted to benzidine which is a human carcinogen

**BIOLOGICAL PROPERTIES:** moderately persistent in water; half-life in water: 20-200 days; can be detected in water using EPA Method 625: gas chromatography plus mass spectrometry; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months

**BIOACCUMULATION:** possible, but little data to support; concentration in fish tissues is expected to be a little higher than the average concentration in the water the fish were taken from

**ORIGIN/INDUSTRY SOURCES/USES:** not a natural chemical; used as a starting material in the manufacture of: benzidine, dyes, and anti-inflammatory drugs, used in synthesis of phenylbutazone which is a powerful inflammatory drug; no longer produced in the U.S.A

**TOXICITY:** freshwater aquatic organisms: LC<sub>50</sub>: 0.27-4.1 mg/L

**EXPOSURE ROUTES:** occupational exposure in dye manufacturing industry and the pharmaceutical industry; ingestion; drinking water

**REGULATORY STATUS:** concentration calculated to keep the lifetime cancer risk level below 10<sup>-5</sup>: 0.4 µg/L; drinking water unit risk by EPA: 2.2 x 10<sup>-5</sup> µg/L; **Criterion to protect freshwater aquatic life:** 270 µg/L based on acute toxicity; 17 µg/L/24 hr avg., concentration not to exceed 38 µg/L any time; **Criterion to protect saltwater aquatic life:** none due to insufficient data; **Criterion to protect human health:** preferably 0; two states set guidelines in drinking water at: 0.45 µg/L

**PROBABLE FATE:** *photolysis:* slow photoreduction to aniline probably leads to the total loss of the compound; *oxidation:* reversible oxidation to azobenzene occurs, photooxidation half-life in water: 1.3 days-72 days, photooxidation half-life in air: 18 minutes; *hydrolysis:* only possible in biosulfite wastes of a paper mill or coal mine; *volatilization:* not important; *biological processes:* bioaccumulation is possible; *other reactions:* intermolecular rearrangement occurs in acidic solution to form benzidine; approximately 84.25% of the pollutant ends up in water; 6.25% ends up in terrestrial soils; 5.8% ends up in aquatic sediments; 3.7% ends up in air

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Aerated lagoons*, 0, negative removal, *Activated sludge*, 0, negative removal, *Powdered activated carbon adsorption* (based on synthetic wastewater), 96, 390

**KEY REFERENCES:** 19; 21; 23; 24; 26, 27; 28

**ALPHA ENDOSULFAN (C<sub>9</sub>H<sub>6</sub>Cl<sub>6</sub>O<sub>3</sub>S, 406.95)****CAS/DOT IDENTIFICATION #:** 959-98-8/UN 2761**SYNONYMS:** 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzo(e)-dioxathiepin-3-oxide, (3alpha,5abeta, 6alpha,9alpha,9abeta)-, Thiodan I, Hexachloro-5-norbornene-2,3-dimethanol, cyclic sulfite, endo-**PHYSICAL PROPERTIES:** technical endosulfan is made up of alpha-endosulfan and beta endosulfan; light to dark-brown crystalline solid; turpentine odor; soluble in ether and benzene; practically insoluble in water; MP (70-100°C); BP (106°C @ 0.7 mmHg); DN (1.735 g/cm<sup>3</sup> @ 20°C); VP (1x10<sup>-5</sup> torr @ 25°C); solubility in water (0.53 mg/L); Log Kow (3.62)**CHEMICAL PROPERTIES:** stable; susceptible to oxidation**BIOLOGICAL PROPERTIES:** 50% degradation in sterile nutrient medium and in a medium inoculated with mixed culture of soil micro-organisms: 12.5 weeks and 1.1 weeks; release to soil will most likely result in biodegradation and hydrolysis; volatilization and leaching are not expected to be significant; total endosulfan can be detected in water by EPA Method 606: methylene chloride extraction followed by gas chromatography with flame ionization or electron detection, or EPA Method 625: gas chromatography plus mass spectrometry**BIOACCUMULATION:** decapod (*Palaemonetes pugio*): 96 hr, 0.16-1.75 µg/L: 81-245X; pelecypod (*Mytilus edulis*): 50 hr, 0.14-2.05 µg/L: 600X; fish (*Lagodon rhomboides*): 96 hr, 0.15-0.26 µg/L: 1046-1299X; fish (*Leiostomus xanthurus*): 96 hr, 0.05-0.31 µg/L: 620-895X; fish (*Mugil cephalus*): 96 hr, 0.32-0.49 µg/L: 1000-1344X; bioconcentration is expected to be significant**ORIGIN/INDUSTRY SOURCES/USES:** not naturally occurring; insecticide for vegetable crops; controls aphids, thrips, beetles, foliar feeding larvae, mites, borers, cutworms, bollworm, bugs, whiteflies, leafhoppers, and slugs on deciduous, citrus, and small fruits, vegetables, crops, grains, tobacco, coffee, tea; controls termites**TOXICITY:** Fish: *Salmo gairdneri*: 96 hr LC<sub>50</sub>: 0.3 µg/L; *Catostomus commersoni*: 96 hr LC<sub>50</sub>: 3.0 µg/L; *Lagodon rhomboides*: 96 hr LC<sub>50</sub> (FT): 0.30 µg/L; *Leiostomus xanthurus*: 96 hr LC<sub>50</sub> (FT): 0.09 µg/L; *Mugil cephalus*: 96 hr LC<sub>50</sub> (FT): 0.38 µg/L; fathead minnow: flow through bioassay: incipient TLM: 0.86 µg/L @ 25°C; chingatta: 96 hr LC<sub>50</sub> (S): 0.011 mg/L; Crustacean: *Gammarus fasciatus*: 96 hr LC<sub>50</sub>: 5.8 µg/L; *Daphnia magna*: 96 hr LC<sub>50</sub>: 52.9 µg/L, 24 hr LC<sub>50</sub>: 240 µg/L, 48 hr LC<sub>50</sub>: 60 µg/L**EXPOSURE ROUTES:** primarily from food; contaminant in air, water, sediment, soil, fish, aquatic organisms, and food; occupational exposure**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** total endosulfan: 0.056 µg/L/24 hr avg., concentration not to exceed 0.22 µg/L any time; **Criterion to protect saltwater aquatic life:** total endosulfan: 0.087 µg/L/24 hr avg., not to exceed 0.034 µg/L any time; **Criterion to protect human health:** total endosulfan: 74 µg/L in drinking water**PROBABLE FATE:** **photolysis:** C-Cl bond photolysis is possible, could be important, may photolyze on the soil surface, when released to the atmosphere, it will react with photochemically produced hydroxyl radicals with an estimated half-life of 1.23 hr, adsorption onto atmospheric particles will increase this half-life; **oxidation:** probably not important, photooxidation by u.v. light in aqueous medium @ 90-95°C, 25% CO<sub>2</sub> formation: 5.0 hr, 50%: 9.5 hr, 75%:

31.0 hr, oxidation rate constant:  $10.4 \times 10^{-3}$  at pH 7, half-life: 66.6 days; **hydrolysis**: hydrolysis of sulfite group may be rapid, probably important above pH 7, hydrolyzed rapidly by alkalis, when released to water, hydrolytic half-life: 35.4 and 150.6 days for pH 7 and 5.5 respectively in the presence of ferric hydroxide, a higher rate of hydrolysis was observed at pH 7 and 20°C, in a solution of ferric oxide, hydrolysis half-life was 8.4 days; **volatilization**: could be important; **sorption**: sorption is an important process; **biological processes**: not important

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon* adsorption (based on synthetic wastewater), ~100, 0.008

**KEY REFERENCES**: 21; 23; 24; 25; 28; 30

### BETA ENDOSULFAN ( $\text{C}_9\text{H}_6\text{Cl}_6\text{O}_3\text{S}$ , 406.95)

**CAS/DOT IDENTIFICATION #**: 33213-65-9/UN 2761

**SYNONYMS**: Endosulfan II, Endosulfan beta, (3alpha,5beta,6beta,9beta,9alpha)-6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-Methano-2,4,3-benzodioxathiepin-3-oxide; Endosulfan 2; 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide, (3alpha, 5alpha, 6beta, 9beta, 9alpha)-; Thiodan II; Hexachloro-5-norbornene-2,3-dimethanol

**PHYSICAL PROPERTIES**: technical endosulfan is made up of alpha-endosulfan and beta endosulfan; light to dark-brown crystalline solid; turpentine odor; soluble in ether and benzene; practically insoluble in water; MP (207-209°C); BP (106°C @ 0.7 mmHg); DN (1.735  $\text{g/cm}^3$  @ 20°C); VP ( $1 \times 10^{-5}$  torr @ 25°C); solubility in water (0.28 mg/L); Log Kow (3.62)

**CHEMICAL PROPERTIES**: stable; susceptible to oxidation

**BIOLOGICAL PROPERTIES**: 50% degradation in sterile nutrient medium and in a medium inoculated with mixed culture of soil micro-organisms: 5.7 weeks and 2.2 weeks; release to soil will most likely result in biodegradation and hydrolysis; volatilization and leaching are not expected to be significant; total endosulfan can be detected in water by EPA Method 606: methylene chloride extraction followed by gas chromatography with flame ionization or electron detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION**: decapod (*Palaemonetes pugio*): 96 hr, 0.16-1.75  $\mu\text{g/L}$ : 81-245X; pelecypod (*Mytilus edulis*): 50 hr, 0.14-2.05  $\mu\text{g/L}$ : 600X; fish: (*Lagodon rhomboides*): 96 hr, 0.15-0.26  $\mu\text{g/L}$ : 1046-1299X; fish (*Leiostomus xanthurus*): 96 hr, 0.05-0.31  $\mu\text{g/L}$ : 620-895X; fish (*Mugil cephalus*): 96 hr, 0.32-0.49  $\mu\text{g/L}$ : 1000-1344X; bioconcentration is expected to be significant

**ORIGIN/INDUSTRY SOURCES/USES**: not naturally occurring; insecticide for vegetable crops; controls aphids, thrips, beetles, foliar feeding larvae, mites, borers, cutworms, bollworm, bugs, whiteflies, leafhoppers, and slugs on deciduous, citrus, and small fruits, vegetables, crops, grains, tobacco, coffee, tea; controls termites

**TOXICITY**: Fish: *Salmo gairdneri*: 96 hr  $\text{LC}_{50}$ : 0.3  $\mu\text{g/L}$ ; *Catostomus commersoni*: 96 hr  $\text{LC}_{50}$ : 3.0  $\mu\text{g/L}$ ; *Lagodon rhomboides*: 96 hr  $\text{LC}_{50}$  (FT): 0.30  $\mu\text{g/L}$ ; *Leiostomus xanthurus*: 96 hr  $\text{LC}_{50}$  (FT): 0.09  $\mu\text{g/L}$ ; *Mugil cephalus*: 96 hr  $\text{LC}_{50}$  (FT): 0.38  $\mu\text{g/L}$ ; fathead minnow: flow through bioassay: incipient TLm: 0.86  $\mu\text{g/L}$  @ 25°C; chingatta: 96 hr  $\text{LC}_{50}$  (S): 0.011 mg/L;

Crustacean: *Gammarus fasciatus*: 96 hr LC<sub>50</sub>: 5.8 µg/L; *Daphnia magna*: 96 hr LC<sub>50</sub>: 52.9 µg/L, 24 hr LC<sub>50</sub>: 240 µg/L, 48 hr LC<sub>50</sub>: 60 µg/L

**EXPOSURE ROUTES:** primarily from food; contaminant in air, water, sediment, soil, fish, aquatic organisms, and food; occupational exposure

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** total endosulfan: 0.056 µg/L/24 hr avg., concentration not to exceed 0.22 µg/L any time; **Criterion to protect saltwater aquatic life:** total endosulfan: 0.087 µg/L/24 hr avg., not to exceed 0.034 µg/L any time; **Criterion to protect human health:** total endosulfan: 74 µg/L in drinking water

**PROBABLE FATE: photolysis:** C-Cl bond photolysis is possible, could be important, may photolyze on the soil surface, when released to the atmosphere, it will react with photochemically produced hydroxyl radicals with an estimated half-life of 1.23 hr, adsorption onto atmospheric particles will increase this half-life; **oxidation:** probably not important, photooxidation by u.v. light in aqueous medium @ 90-95°C, 25% CO<sub>2</sub> formation: 5.0 hr, 50%: 9.5 hr, 75%: 31.0 hr, oxidation rate constant:  $9.7 \times 10^{-3}$  at pH 7, half-life: 71.4 days; **hydrolysis:** hydrolysis of sulfite group may be rapid, probably important above pH 7, hydrolyzed rapidly by alkalies, when released to water, hydrolytic half-life: 37.5 and 187.3 days for pH 7 and 5.5 respectively, in the presence of ferric hydroxide, a higher rate of hydrolysis was observed at pH 7 and 20°C, in a solution of ferric oxide, hydrolysis half-life was 9.4 days; **volatilization:** could be important; **sorption:** sorption is an important process; **biological processes:** not important

**TREATABILITY/REMOVABILITY (Process, Removable Range (%), Avg. Achievable Conc. (µg/L)):** *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon* adsorption (based on synthetic wastewater), ~100, 0.2

**KEY REFERENCES:** 21; 23; 24; 25; 28; 30

## ENDOSULFAN SULFATE (C<sub>9</sub>H<sub>6</sub>Cl<sub>6</sub>O<sub>4</sub>S, 422.92)

**CAS/DOT IDENTIFICATION #:** 1031-07-8/UN 2761

**SYNONYMS:** 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-Methano-2,4,3-benzodioxathiepin 3,3-dioxide, Thiodan sulfate, Hexachloro-5-norbomene-2,3-dimethanol, cyclic sulfate, endosulfan sulfanate

**PHYSICAL PROPERTIES:** MP (181°C); solubility in water (0.177 mg/L); Log Kow (3.66)

**CHEMICAL PROPERTIES:** stable

**BIOLOGICAL PROPERTIES:** not expected to leach into ground water; biodegradation may be an important fate process with a half-life of 11 weeks for endosulfan sulfate incubated with mixed cultures from a sandy loam soil; not degraded in standard screening tests using settled domestic wastewater as inoculum; 50% degradation in sterile nutrient medium and in a medium inoculated with mixed culture of soil micro-organisms: >20 weeks and 11 weeks; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with flame ionization or electron detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** if released to water, it may bioconcentrate in aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES:** not commercially produced; endosulfan is a precursor

**TOXICITY:** data is unavailable, see entries for alpha endosulfan and beta endosulfan

**EXPOSURE ROUTES:** primarily from ingestion of contaminated food

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** total endosulfan: 0.056 µg/L/24 hr avg., concentration not to exceed 0.22 µg/L any time; **Criterion to protect saltwater aquatic life:** total endosulfan: 0.087 µg/L/24 hr avg., not to exceed 0.034 µg/L any time; **Criterion to protect human health:** total endosulfan: 74 µg/L in drinking water

**PROBABLE FATE:** **photolysis:** no information is available, may not be an important fate process based on the stability of thin films exposed to light >300 nm, if released to the atmosphere, it will react with hydroxyl radicals, with a half-life of 1.23 hr; **oxidation:** probably not important; **hydrolysis:** probably an important process, hydrolysis half-lives of endosulfan isomers: 35.4-37.5 days at pH 7 and 150.6-187.3 days at pH 5.5; **volatilization:** no information available, evaporation from water is probably an important fate process based on an estimated half-life of 43 hr from a river 1m deep, flowing 1 m/s and a wind velocity of 3 m/s, evaporation from lakes and deeper streams and rivers will be slower; **sorption:** no information available, if released to soil, it will be expected to bind to the soil, if released to water, it will be expected to bind to the sediment; **biological processes:** no information available

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon* adsorption (based on synthetic wastewater), ~100, 0.03

**KEY REFERENCES:** 21; 23; 25; 28; 30

## ENDRIN (C<sub>12</sub>H<sub>8</sub>Cl<sub>6</sub>O, 380.9)

**CAS/DOT IDENTIFICATION #:** 72-20-8/UN 2761

**SYNONYMS:** 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,2-endo-endo-5,8-dimethano-naphthalene, nendrin; endrex

**PHYSICAL PROPERTIES:** white, crystalline solid; mild chemical odor; MP (200°C); BP (decomposes); SG (1.7 @ 20°C); VP (2x10<sup>-7</sup> torr @ 25°C); solubility in water (0.26 mg/L @ 25°C); OT (1.8x10<sup>-2</sup> ppm); Log Kow (5.6); H (4x10<sup>-7</sup> atm-m<sup>3</sup>/mole); Log Poct (5.6)

**CHEMICAL PROPERTIES:** incompatible with strong oxidizers and strong acids; non-flammable; reacts with metal salts and catalytically active carriers; strongly corrosive to metals

**BIOLOGICAL PROPERTIES:** will not leach to groundwater; will reach surface water with surface runoff; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with electron capture or halogen specific detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** Mussels: pelecypod (*Mytilus edulis*): 50 hr, 0.17-1.78 µg/L: 1920X; BCF (5 aquatic molluscs): 500-1250X; oyster (*Crassostrea virginica*): BCF after 168 hr exposure: 1670-2780 (in whole body), biological half-life following 168 hr exposure: 67 hr (in whole body); freshwater mussel (*Lampsilis siliquoidea*): BCF: 1200, half-life: 4.7 days; Fish:

BCF (mosquito fish): 10 (25 min. exposure); fathead minnows (10,000); Log BCF (rainbow trout (*Salmo gairdneri*)): 3.17; BCF from food (fathead minnows): 0.8, from water: 13,000; once it reaches surf waters, it will bioconcentrate in fish

**ORIGIN/INDUSTRY SOURCES/USES:** insecticide used mainly on field crops to control the army cutworm, the pale cutworm, pine vole, meadow voles, and grasshoppers; minor constituent in dieldrin; pesticide (former use)

**TOXICITY:** Fish: largemouth bass (*Micropterus salmoides*): static bioassay: 48 hr TLM: 0.27 µg/L @ 19°C; *O. punctatus*: 96 hr LC<sub>50</sub>: 0.033 ppm; *Pimephales promelas*: 96 hr, LC<sub>50</sub>: 1.0 µg/L; *Lepomis macrochirus*: 96 hr, LC<sub>50</sub>: 0.6 µg/L; *Salmo gairdneri*: 96 hr, LC<sub>50</sub>: 0.5 µg/L; striped killfish (*Fundulus majalis*): 96 hr static lab bioassay: LC<sub>50</sub>: 0.3 ppb; bluehead (*Thalassoma bifasciatum*): 96 hr static lab bioassay: LC<sub>50</sub>: 0.1 ppb; American eel (*Anguilla rostrata*): 96 hr static lab bioassay: LC<sub>50</sub>: 0.6 ppb; many more referenced below

**EXPOSURE ROUTES:** occupational exposure; formulation, manufacture, and field application of this pesticide; inhalation; skin adsorption; ingestion; eye and skin contact; contaminated air, water, soil, fish, and other aquatic organisms

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.0023 µg/L/24 hr avg., not to exceed 0.18 µg/L any time; **Criterion to protect saltwater aquatic life:** 0.0023 µg/L/24 hr avg., not to exceed 0.037 µg/L any time; **Criterion to protect human health:** 1.0 µg/L; limit from tap water (UN publication): 0.2 µg/L; long-term health advisory by EPA: 16 µg/L; lifetime health advisory: 0.32 µg/L; Mexico limits: 2 µg/L in estuaries, 1 µg/L in receiving waters used for drinking water, and 0.2 µg/L in coastal waters; guidelines in drinking water set by Maine: 0.2 µg/L; standard by Maine: 0.2 µg/L

**PROBABLE FATE:** **photolysis:** photoisomerization occurs, may be important, photo-oxidation by u.v. light in aqueous medium @ 90-95°C, 25% CO<sub>2</sub> formation: 15.0 hr, 50%: 41 hr, 75%: 172 hr, photodegrades to delta-ketoendrin with a half-life of 7 days, a half-life of 1.45 hrs is expected for reaction with hydroxyl radicals; **oxidation:** probably not important; **hydrolysis:** hydrolysis of epoxide, too slow to be important; **volatilization:** not an important process, will eventually reach the air through slow evaporation; **sorption:** information is unavailable, when released to soil, it will persist for long periods (greater than 14 yrs), will eventually reach the air through adsorption onto dust particles, once it reaches surface water, it will adsorb strongly to sediments; **biological processes:** bioaccumulation is an important process

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon* adsorption (based on synthetic wastewater), 99, 0.6; removed mainly by *rainout* and *dry deposition*

**KEY REFERENCES:** 21; 23; 25; 28; 30

## **ENDRIN ALDEHYDE (C<sub>12</sub>H<sub>6</sub>Cl<sub>6</sub>O, 380.89)**

**CAS/DOT IDENTIFICATION #:** 7421-93-4/UN not available

**SYNONYMS:** 1,2,4-methenocyclopenta (c,d) pentalene-r-carboxaldehyde, 2,2a,3,3,4,7-hexachlorodecahydro; endrinaldehyde

**PHYSICAL PROPERTIES:** MP (149-154°C); VP (2x10<sup>-7</sup> mmHg @ 25°C, estimated)

**CHEMICAL PROPERTIES:**-data not available

**BIOLOGICAL PROPERTIES:** Koc (estimated): 8,500 to 45,000; if released to soil, it is not expected to leach in most soil types; no data available to predict biodegradability; if released to the air, it will probably exist mainly in the adsorbed phase

**BIOACCUMULATION:** bioconcentration is expected to be an important fate process if released to water

**ORIGIN/INDUSTRY SOURCES/USES:** not commercially used; impurity of endrin; released to environment during application of endrin as an insecticide; is a metabolite of endrin

**TOXICITY:** data not available

**EXPOSURE ROUTES:** occupational workers involved in the manufacture, formulation and application of the insecticide endrin exposure via inhalation; dermal exposure is possible

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** data not available; **Criterion to protect saltwater aquatic life:** data not available; **Criterion to protect human health:** data not available

**PROBABLE FATE:** **photolysis:** data not available; **oxidation:** oxidation by peroxy radicals or singlet oxygen is not expected to be important; **hydrolysis:** aquatic hydrolysis is not expected to be significant; **volatilization:** volatilization is not expected to be significant or important; **sorption:** if released to water, adsorption to sediments appears to be the important fate process; **biological processes:** bioconcentration is expected to be an important fate process if released to water

**TREATABILITY/REMOVABILITY** particulates associated with endrin aldehyde will be subject to wet and dry deposition

**KEY REFERENCES:** 23; 28; 30

### **ETHYLBENZENE (C<sub>8</sub>H<sub>10</sub>, 106.18)**

**CAS/DOT IDENTIFICATION #:** 100-41-4/UN 1175

**SYNONYMS:** benzene ethyl, eb, ethyl-benzene, ethylbenzol, phenylethane

**PHYSICAL PROPERTIES:** colorless liquid; aromatic odor; negligibly soluble in water; miscible in alcohol and ether; soluble in ethyl alcohol, ethyl ether and water; MP (-95.01°C); BP (136.25°C); ST (31.50 dynes/cm); DN (0.867 g/mL @ 20°C); SG (0.867); VP (7 torr @ 20°C); VD (3.66); VS (0.64 cP @ 25°C); solubility (140 mg/L @ 15°C); HV (9301.3 gcal/gmole); Log Kow (3.15); H (6.44 atm·m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** reacts strongly with oxidizing agents;; HC (-9,877 cal/g); FP (18°C); AT (810°C); LFL/UFL (1%, 6.7%)

**BIOLOGICAL PROPERTIES:** ThOD: 3.17; 27% theoretical oxidation of 500 ppm solution by phenol-acclimated activated sludge after 12 hr aeration; incubation with natural flora in the groundwater, in presence of the other components of high-octane gasoline (100 µl/L): biodegradation: 100% after 192 hr @ 13°C (initial concentration: 1.36 µl/L); estimated half-life

under photochemical smog conditions: 4.6 hr; soil, surface water, and aerobic half-lives: 3-10 days; ground water half-life: 6-228 days; anaerobic half-life: 176-228 days; can be detected in water by EPA Method 602: inert gas purge followed by gas chromatography and photoionization detection, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** : Log BCF (goldfish):1.19; Log BCF (clams):0.67; Log BCF (regression equations in fish): 2.16; very little potential for bioaccumulation; the concentration found in fish tissues is expected to be somewhat higher than the average concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** made by petroleum refining; intermediate in the production of styrene; production of synthetic rubber as a solvent or diluent; component of automotive and aviation fuels; manufacture of cellulose acetate; unrecovered component of gasoline; solvent for propylene oxide

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 12 mg/L, algae (*Microcystis aeruginosa*): 33 mg/L, green algae (*Scenedesmus quadricauda*): >160 mg/L, protozoa (*Entosiphon sulcatum*): 140 mg/L; protozoa (*Uronema parduczi Chatton-L woff*): >110 mg/L; Fish: fatheads: soft water: TLm (25-96 hr): 48.5 mg/L, hard water: 42.3 mg/L; bluegills, goldfish, guppies: soft water: 35.1-32 mg/L, 94.4 mg/L, 97.1 mg/L respectively

**EXPOSURE ROUTES:** mainly by inhalation; occupational exposure in industries that use ethyl benzene; possible adsorption through skin and eyes

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 32,000 µg/L based on acute toxicity; **Criterion to protect saltwater aquatic life:** 430 µg/L based on acute toxicity; **Criterion to protect human health:** 1.4 mg/L; lifetime health advisory proposed by EPA: 0.68 mg/L; USSR MAC in water bodies used for domestic purposes: 0.01 mg/L; in water bodies used for fishery purposes: 0.011 mg/L; the following are guidelines in drinking water set by some states: 1 µg/L (Illinois), 680 µg/L (Arizona, California, Kansas, Minnesota), 750 µg/L (New Mexico), 1400 µg/L (Vermont and Wisconsin)

**PROBABLE FATE:** **photolysis:** photooxidation after volatilization is the principal fate, photooxidation half-life in air: 8.56 hrs-3.57 days, reaction with photochemically produced hydroxyl radicals: hours to 2 days; **oxidation:** not important other than in the case of photooxidation; **hydrolysis:** not important; **volatilization:** principal transport process; **sorption:** probably adsorbed by organic materials; **biological processes:** very little potential for bioaccumulation, can be used as sole carbon source by some microbes

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, >50; *Gas flotation*, >99, not detected; *Gas flotation with chemical addition (calcium chloride, polymer)*, 40->99, 280; *Gas flotation with chemical addition (polymer)*, 65, 160; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, >75->99, <2.1; *Sedimentation*, 47-78, 1000; *Sedimentation with chemical addition (alum, lime)*, >97-99, 11; *Sedimentation with chemical addition (polymer)*, 81, 130; *Sedimentation with chemical addition (alum, polymer)*, >80->94, 430; *Sedimentation with chemical addition (alum)*, 0, negative removal; *Aerated lagoons*, >78->94, <10; *Solvent extraction*, 97, 4000; *Activated sludge*, 80->99, 170; *Granular activated carbon adsorption*, 0, negative removal; *Powdered activated carbon adsorption*, 87, 18000; *continuous activated sludge biological treatment simulators*: 73-95% removal

**KEY REFERENCES:** 11; 19; 21; 22; 23; 25; 26; 27

**FLUORANTHENE (C<sub>16</sub>H<sub>10</sub>, 202.26)****CAS/DOT IDENTIFICATION #:** 206-44-0/UN not available**SYNONYMS:** 1,2-benzacenaphthlene, benzo (j,k) fluorene, idryl**PHYSICAL PROPERTIES:** colorless crystalline solid; MP (111°C); BP (375°C); SG (1.252); VP (10<sup>-6</sup> – 10<sup>-4</sup> torr @ 20°C); solubility in water (0.26 mg/L); Log Kow (5.33)**CHEMICAL PROPERTIES:** probably combustible**BIOLOGICAL PROPERTIES:** in leachate from test panels freshly coated with coal tar: influent: 0.003 µg/L, effluent: 0.081 µg/L; domestic sewage effluent: 0.00001 mg/L; primary and digested raw sewage sludge: 0.525-1.2 ppm; sludge cake from heat treatment plants: 0.47-1.6 ppm; surface water half-life: 21 hrs-2.6 days; ground water half-life: 280 days-2.41 yrs; stable in sediment for decades; can be transported to groundwater; expected to biodegrade in a few yrs in the presence of acclimated microorganisms; photochemical smog situations enhance the degradation of both the sorbed molecule and the free vapor; soil and aerobic half-life: 140-440 days; anaerobic half-life: 1.53-4.82 yrs; can be detected in water by EPA Method 610: methylene chloride extraction followed by high pressure liquid chromatography with fluorescence as UV detection or gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry**BIOACCUMULATION:** will bioconcentrate in aquatic organisms when released to water; concentrations found in shellfish such as clams and mussels can indicate where pollution is in localized areas**ORIGIN/INDUSTRY SOURCES/USES:** produced from pyrolytic processing of organic raw materials such as coal and petroleum at high temperatures; product of plant biosynthesis; used as a lining material to protect interior of steel and ductile-iron portable water pipes and storage tanks; research chemical**TOXICITY:** uptake and depuration by Oysters (*Crassostrea virginica*) from oil treated enclosure: half-life for depuration: 5 days; *Neanthes arenaceodentata*: 96 hr TLm in seawater @ 22°C: 0.5 ppm (initial concentration in static assay)**EXPOSURE ROUTES:** drinking water; cigarette smoke; fossil fuel burning; coke oven workers, steel workers, roofers, and automobile mechanics; tobacco smokers; ambient air; ingesting contaminated food**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 3,980µg/L based on acute toxicity; **Criterion to protect saltwater aquatic life:** 40 µg/L based on acute toxicity, 16 µg/L based on chronic toxicity; **Criterion to protect human health:** 42 µg/L; WHO: 0.2 µg/L for polyaromatic hydrocarbons; Kansas guideline in drinking water: 0.029 µg/L**PROBABLE FATE:** **photolysis:** insufficient data, but photolysis may be very important, atmospheric and aqueous photolytic half-lives: 21 hrs-2.6 days, in the unadsorbed state, it will degrade by photolysis with a half-life of a few days to a week; **oxidation:** chlorine and/or ozone in sufficient quantities may oxidize fluoranthene, photooxidation half-life in air: 2.02-20.2 hrs; **hydrolysis:** not an important process; **volatilization:** not an important transport process; **sorption:** adsorption onto suspended solids and sediments is probably the dominant transport process, when released to water, it will quickly adsorb to sediment and particulate matter in the water

column; **biological processes:** short-term bioaccumulation, biodegradation is a very important fate

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Gravity oil separation*, not available, 60; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Filtration*, 29-50, 0.11; *Sedimentation*, 17->64, <17; *Sedimentation with chemical addition (lime, polymer)*, >97, <10; *Ozonation*, 50, 0.1; *Activated sludge*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Granular activated carbon adsorption*, >82->90, <0.02; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 0.5; subject to *gravitational settling and rainout*

**KEY REFERENCES:** 21; 23; 25; 26; 28; 30

## FLUORENE ( $\text{C}_{13}\text{H}_{10}$ , 166.22)

**CAS/DOT IDENTIFICATION #:** 86-73-7/UN not available

**SYNONYMS:** 2,3-Benzidene, diphenylenemethane, o-biphenylmethane; alpha-diphenylenemethane-9<sup>th</sup>-fluorene

**PHYSICAL PROPERTIES:** leaflets or flakes; white; MP (116-117°C); BP (293-295°C); DN (1.203  $\text{g/cm}^3$  @ 0°C); SG (1.203); VP ( $10^{-3}$ - $10^{-2}$  @ 20°C); solubility (1.98  $\text{mg/L}$  @ 25°C); Log Kow (4.18); H (0.177 $\times 10^{-3}$  atm- $\text{m}^3/\text{mol}$ )

**CHEMICAL PROPERTIES:** very stable; sublimes easily under a vacuum

**BIOLOGICAL PROPERTIES:** Koc: 3.7-4.21; immobile in soil; in leachate from test panels freshly coated with coal tar: influent: 0.001  $\mu\text{g/L}$ , effluent: 0.021  $\mu\text{g/L}$ ; biodegradation to  $\text{CO}_2$ ; degradation in seawater by oil-oxidizing micro-organisms (in presence of 0.19  $\text{mg/L}$  3,4-benzpyrene and 0.365  $\text{mg/L}$  pyrene): initial concentration 0.35  $\text{mg/L}$  after 12 days: 0.27  $\text{mg/L}$ , a 23% decrease; microbial degradation to  $\text{CO}_2$  in seawater @ 12°C in the dark after 48 hr incubation at 30 $\mu\text{g/L}$ : nil, after addition of water extract of no. 2 fuel oil; if released to air, will exist mainly in the vapor phase; capable of long range global transport; if released to soil or water, will biodegrade aerobically in the presence of acclimated microbes; biodegradation expected to be slow in pristine soils or waters, or under conditions of limited oxygen; soil, surface water, and aerobic half-life: 32-60 days; ground water half-life: 64-120 days; anaerobic half-life: 128-240 days

**BIOACCUMULATION:** bioaccumulation is short-term

**ORIGIN/INDUSTRY SOURCES/USES:** in commercial coal tar; in wood preservative sludge; chemical intermediate in many miscellaneous applications; formation of polyradicals for resins; dyestuffs; derivatives of fluorene show activity as herbicides and growth regulators; in fossil fuels

**TOXICITY:** *Neanthes arenaceodentata*: 96 hr TLm in seawater @ 22°C: 1.0 ppm (initial concentration in static assay)

**EXPOSURE ROUTES:** airborne coal tar emissions; combustion of oil, gasoline, wood and refuse; detected in rain, snow, and fog; smoking tobacco; inhalation of polluted air; ingestion of food and water contaminated by combustion effluents

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** data not available; **Criterion to protect saltwater aquatic life:** data not available; **Criterion to protect human health:** data not available

**PROBABLE FATE:** *photolysis:* may be important, but is probably impeded by adsorption, photooxidation by U.V. in aqueous medium @ 90-95°C: time for the formation of CO<sub>2</sub> (% of theoretical): 25%: 75.3 hr, 50%: 160.6 hr, 75%: 297.4 hr, photooxidation half-life in air: 6.81 hrs-2.8 days, degrades quickly by photochemically produced hydroxyl radicals, with an estimated half-life of 29 hr; *oxidation:* chlorine and/or ozone in sufficient quantities may oxidize fluorene; *hydrolysis:* not an important process; *volatilization:* probably not an important transport process, volatilization half-lives from a model river and a model pond: 15 and 167 respectively; *sorption:* adsorption onto particles, biota, and sediments is probably the dominant transport process, half-life in soil ranges from 2-64 days; *biological processes:* bioaccumulation is short-term, metabolization and biodegradation are very important fates; in estuarine waters: @ 15µg/L, 12% adsorbed on particles after 3 hr

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 140; *Filtration*, 0, negative removal; *Sedimentation*, >79, <10; *Sedimentation with chemical addition (lime, polymer)*, 50->99, <7.5; *Ozonation*, 67, 0.1; *Activated sludge*, >99, <0.021; *Activated sludge* (based on synthetic wastewater), 82, 900; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 2; *continuous activated sludge biological treatment simulator:* 44% removal; can be physically removed from particulates by *wet and dry deposition*

**KEY REFERENCES:** 23; 25; 26; 28; 30

## HEPTACHLOR (C<sub>10</sub>H<sub>5</sub>Cl<sub>7</sub>, 373.32)

**CAS/DOT IDENTIFICATION #:** 76-44-8/UN 2761

**SYNONYMS:** agroceres, amatin, anticarie, bunt-cure, bunt-no-more, 3-chlorochlordene, co-op hexa, drinox, ent-15, 152, esachlorobenzene, goldcrest, H-60, heptox, many more

**PHYSICAL PROPERTIES:** white powder or a light tan waxy solid; camphor-like odor; soluble in organic solvents and flammable liquids; MP (95-96°C); BP (135-145°C); DN (1.57 g/cm<sup>3</sup>); SG (1.66); VP (3 mmHg @ 25°C); solubility (0.0006% by weight in water @ 20°C, 0.056 mg/L @ 20°C); OT (0.02 ppm in water); Log Kow (3.87-5.44); H (1.48x10<sup>-3</sup> atm<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** noncombustible; incompatible with strong alkali; corrosive to metals; reacts with iron and rust to form toxic gases; reacts vigorously with oxidizing materials; susceptible to epoxidation

**BIOLOGICAL PROPERTIES:** 75-100% disappearance from soils: 2-5 yrs; persistence in river water in a sealed glass jar under sunlight and artificial fluorescent light, initial concentration 10 µg/L, after 1 hr: 100%, after 1 week: 25%, after 2 weeks, 0% of original compound found; conversion to 1-hydroxychlorodene was complete in 2 weeks in river water under the same conditions; % degraded under aerobic conditions: 53-65%; resists leaching to ground water; soil, surface water, and ground water half-life: 23.1 hours-5.4 days; aerobic half-life: 15-65 days; anaerobic half-life: 60-360 days; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with electron capture or halogen specific detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** molluscs: 5 aquatic molluscs: 250-25,00X; oysters: 17,600X; Crustaceans: pelecypod (*Crassostrea virginica*): 0.083-14 µg/L, 96 hr: 3,900-85,00X; decapod (*Penaeus duorarum*): 0.04-0.2 µg/L, 96 hr: 200-300X; fish: (*Cyprinodon variegatus*): 2.7-8.8 µg/L, 96 hr: 7,400-21,300X; (*Lagodon rhomboides*): 0.20-4.4 µg/L, 96 hr: 2,800-77,00X; trout: 300X; builds up in the tissues of fish and cattle

**ORIGIN/INDUSTRY SOURCES/USES:** pesticides; insecticides; killing insects in homes, buildings, and on food crops in the past

**TOXICITY:** Crustaceans: (*Gammarus lacustris*, *Gammarus fasciatus*, *Palaemonetes kadiakensis*, *Orconectes nais*): 96 hr LC<sub>50</sub>: 29, 40, 1.8, and 7.8 µg/L respectively; *Simocephalus serrulatus* and *Daphnia pules*: 48 hr LC<sub>50</sub>: 47 and 42 µg/L respectively; Fish: (*Pimephales promelas*, *Lepomis macrochirus*, *Lepomis microlophus*, *Salmo gairdneri*): 96 hr LC<sub>50</sub>: 56, 19, 17, and 19 µg/L respectively; bluegill: 96 hr LC<sub>50</sub>: 0.190 ppm; rainbow trout: 96 hr LC<sub>50</sub>: 0.150 ppm; minnow: 24 hr LC<sub>50</sub>: 13 ppb; and more from references below

**EXPOSURE ROUTES:** ingestion; skin contact; inhalation; subsurface ground injection as an insecticide; manufacture, formulation, application of insecticide; mothers' milk; cows' milk; commercially prepared baby foods

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life: 0.0038 µg/L/24 hr avg., concentration not to exceed 0.52 µg/L; Criterion to protect saltwater aquatic life: 0.0036 µg/L/24 hr avg., concentration not to exceed 0.053 µg/L; Criterion to protect human health: preferably 0; lifetime cancer risk of 1 in 100,000: 2.78 ng/L; lifetime health advisory: 17.5 µg/L; Mexico limits in drinking water, coastal water, and estuaries: 0.018 mg/L, 0.2 µg/L, and 2.0 µg/L, respectively; USSR limit: 50 µg/L in water bodies used for domestic purposes; WHO: 1 µg/L in drinking water; drinking water maximum contaminant levels: 0.4 µg/L; Illinois standard: 0.1 µg/L; the following are guidelines in drinking water set by some states: 0.02 µg/L (California), 0.1 µg/L (Minnesota), 0.104 µg/L (Kansas), 0.23 µg/L (Maine), 0.50 µg/L (Arizona)

**PROBABLE FATE:** *photolysis*: photoisomerization occurs, rate undetermined, photo-oxidation half-life in air: 59 minutes-9.8 hrs, vapor phase heptachlor in air will react with photochemically produced hydroxy radicals, half-life: 36 min., direct photolysis may occur; *oxidation*: information is not available; *hydrolysis*: rapid hydrolysis for heptachlor in solution, first-order hydrolytic half-life: 23.1 hrs or 129.4 hrs, significant in moist soils; *volatilization*: expected to be an important process, evaporates slowly, release to soil will result in volatilization from the surface, especially in moist soils; *sorption*: probably an important process, but no reliable data is available, sticks strongly to soil particles; *biological processes*: will bioaccumulate if not hydrolyzed, biodegradation is significant

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Activated sludge*, 76, 1.5; *Activated sludge* (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption* (based on synthetic wastewater), 97, 5.8

**KEY REFERENCES:** 19; 21; 23; 25; 26; 28; 30; 31

## HEPTACHLOR EPOXIDE (C<sub>10</sub>H<sub>5</sub>CL<sub>7</sub>O, 389.30)

**CAS/DOT IDENTIFICATION #:** 1024-57-3/UN 2761

**SYNONYMS:** epoxyheptachlor, Velsicol 53-CS-17®, 1,4,5,6,7,8,8-heptachloro-2,3-epoxy-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene

**PHYSICAL PROPERTIES:** solid; MP (160-161.5°C); solubility (0.35 mg/L @ 25°C); OT (0.02 ppm); H ( $3.2 \times 10^{-5}$  atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** stable

**BIOLOGICAL PROPERTIES:** persistence in river water in a sealed glass jar under sunlight and artificial fluorescent light, initial concentration 10 µg/L, after 1 hr: 100%, after 1 week: 100%, after 8 weeks, 100% of original compound found; adsorbs strongly to soil; can stay in the soil and in the water for many years; extremely resistant to biodegradation; long range dispersal and transport occurs; soil, surface water, and aerobic half-life: 33-552 days; ground water half-life: 1-1104 days; anaerobic half-life: 1-7 days; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with electron capture or halogen specific detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** pelecypod (*Mytilus edulis*): exposure: 0.22-1.95 µg/L, 50hr: BCF: 17,00X; builds up in the tissues of fish and cattle; bioconcentrated extensively; taken up into the food chain by plants and bioconcentrates into fish, animals and milk

**ORIGIN/INDUSTRY SOURCES/USES:** oxidation product of heptachlor formed by plants and animals, including humans, after exposure to heptachlor; contaminant in heptachlor; not available as a commercial product in the USA; not present in commercial form

**TOXICITY:** decapod (*Penaeus duorarum*): 96 hr LC50 (FT): effective concentration: 0.04 µg/L

**EXPOSURE ROUTES:** ingestion; skin contact; inhalation; subsurface ground injection as an insecticide; manufacture, formulation, application of insecticide; mothers' milk; cows' milk; commercially prepared baby foods; eating meat and fish, therefore lower concentration in milk of vegetarians

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life: 0.0038 µg/L/24 hr avg., concentration not to exceed 0.52 µg/L; Criterion to protect saltwater aquatic life: 0.0036 µg/L/24 hr avg., concentration not to exceed 0.053 µg/L; Criterion to protect human health: preferably 0; lifetime cancer risk of 1 in 100,000: 2.78 ng/L; lifetime health advisory: 0.4 µg/L; Mexico limits in drinking water: 0.018 mg/L; drinking water maximum contaminant levels: 0.2 µg/L; Illinois standard: 0.1 µg/L; the following are guidelines in drinking water set by some states: 0.1 µg/L (California), 0.006 µg/L (Kansas and Minnesota)

**PROBABLE FATE:** *photolysis*: possible dechlorination of C=C bond, photooxidation half-life in air: 6 hrs-2.5 days, vapor phase reactions with photochemically produced hydroxyl radicals have a half-life of 1.5 days; *oxidation*: not expected to be important; *hydrolysis*: very slow, not expected to be important; *volatilization*: not an important process, evaporates slowly to air, volatilization from a model river: 60 hr; *sorption*: occurs to a moderate degree, sticks strongly to soil particles, if released to water, will adsorb strongly to suspended and bottom sediment; *biological processes*: biotransformation occurs very slowly, but could be important

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Sedimentation with chemical addition (alum, lime)*, >29, <1; *Activated*

ludge (based on synthetic wastewater), 0, not available; *Powdered activated carbon adsorption* based on synthetic wastewater), ~100, 0.4; subject to *gravitational settling and washout by rain*

**KEY REFERENCES:** 21; 23; 25; 26; 28; 30; 31

## HEXACHLOROBENZENE (C<sub>6</sub>Cl<sub>6</sub>, 285.2)

**CAS/DOT IDENTIFICATION #:** 118-74-1/UN 2729

**SYNONYMS:** amatin, anticarie, bunt-cure, co-op hexa, granox nm, no bunt 40, pentachlorophenyl chloride, perchlorobenzene, sanocid, many others

**PHYSICAL PROPERTIES:** white needles; soluble in benzene and boiling alcohol; insoluble in water; MP (227°C); BP (323°C); DN (2.044 g/cm<sup>3</sup> @ 23°C); VP (0.00001 mmHg @ 20°C); VD (9.8 g/m<sup>3</sup>); solubility in water (6 µg/L @ 25°C); OT (3 ppm); Log Kow (6.18); H (1.70x10<sup>-3</sup> atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** incompatible with strong oxidizing agents; reacts violently with dimethylformamide; FP (241°C); AT (596.2°C)

**BIOLOGICAL PROPERTIES:** very persistent environmental chemical; no degradation by *Pseudomonas* @ 30°C in 120 hr; long range global transport is possible; generally not susceptible to leaching; soil, surface water, and aerobic half-lives: 2.7-5.7 yrs; ground water half-life: 5.3-11.4 yrs; anaerobic half-life: 10.6-22.9 yrs; can be detected in water by EPA Method 612: methylene chloride extraction followed by concentration and gas chromatography with electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (bacteria): 50,000; BCF (algae): 320-1,570; BCF (snails): 1,360-3,320; BCF (daphnids): 770-1,030; BCF (fish): 1,160-3,740; BCF (guppies (*Poecilia reticulata*)): 290,000 (on lipid content); fish: trout: Log BCF: 3.89; the concentration found in fish tissues is expected to be considerably higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** pesticide; fungicide; intermediate for the synthesis of wood preservatives, the synthesis of rubber, and dyes; additive for pyrotechnic compounds for military uses; porosity controller in the manufacture of electrodes; organic synthesis; wood preservative

**TOXICITY:** Algae (*Chlorella pyrenoidosa*): strain 211-8b: inhibition of photosynthetic oxygen evolution of 33.3% @ 0.1 ppm, 42% @ 1.0 ppm, 51% @ 5.0 ppm, respiration was inhibited only slightly, if at all at levels of 0.1-5.0 ppm; fish: guppy (*Poecilia reticulata*): 14 d LC50: >0.32 ppm

**EXPOSURE ROUTES:** ingestion; inhalation of vapor; adsorption through skin; air emissions and wastewater; flue gases and fly ash from waste incineration; ambient air; contaminated food, water, and soil; detected in food during market based surveys

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** data not available; **Criterion to protect saltwater aquatic life:** data not available; **Criterion to protect human health:** USSR MAC: 0.05 mg/L in water used for domestic purposes; long term health advisory: 175 µg/L; lifetime health advisory: 28 µg/L; lifetime cancer risk level of 1 in 100,000: 7.2 ng/L; WHO: 0.01 µg/L limit in drinking water; the following are guidelines in drinking wa-

ter set by some states: 0.02 µg/L (Arizona), 0.20 µg/L (Kansas), 0.21 µg/L (Minnesota), 5.4 µg/L (Maine)

**PROBABLE FATE:** *photolysis*: extremely slow under environmental conditions, photo oxidation half-life in air: 156.4 days-4.2 yrs, estimated half-life with hydroxyl radicals is 2 yrs *oxidation*: not important; *hydrolysis*: not important; *volatilization*: volatilization is rapid from the water column, however, is probably not important as compared to adsorption, the evaporation rate from water has a half-life of approximately 8 hrs from a 1m deep water column; *sorption*: strongly sorbed by particulate matter; *biological processes*: strongly bioaccumulated by many organisms, extremely slow biodegradation

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Aerated lagoons*, 0, negative removal; *Activated sludge*, 47->97, 0.4; *Activated sludge* (based on synthetic wastewater), 56, 2200; *Powdered activated carbon adsorption* (based on synthetic wastewater), 90, 79,000; can be physically removed by *washout by rainfall and dry deposition*

**KEY REFERENCES:** 11; 19; 21; 23; 25; 26; 27; 28; 30

### HEXACHLOROBUTADIENE (C<sub>4</sub>Cl<sub>6</sub>, 260.76)

**CAS/DOT IDENTIFICATION #:** 87-68-3/UN 2279

**SYNONYMS:** perchlorobutadiene, 1,3-hexachlorobutadiene, dolen-pur, HCB

**PHYSICAL PROPERTIES:** clear, colorless liquid; faint, turpentine odor; soluble in alcohol and ether; MP (-21°C); BP (215°C); DN (1.675 g/cm<sup>3</sup> @ 16°C); SG (1.675); VP (0.15 ton @ 20°C); VS (2.447 cP @ 37.7°C); VD (8.99); solubility in water (2 mg/L @ 20°C); OT (1.0 ppm); Log Kow (4.90); H (10.3x10<sup>-3</sup> atm-m<sup>3</sup>/mole); refractive index (1.550 @ 20°C)

**CHEMICAL PROPERTIES:** incompatible with strong oxidizing agents; compatible with numerous resins; nonflammable; AT (610°C)

**BIOLOGICAL PROPERTIES:** Koc: 5,181; leaching is only expected to be quick in sandy soils; % degraded under anaerobic continuous flow conditions: 4%; in air, half of it may be broken down to other chemicals within 60 days; in water, half of it may be broken down to other chemicals within 30 days; readily breaks down in soil; considerable dispersion is expected; did not biodegrade in an anaerobic culture incubated for 48 hrs @ 37°C; under anaerobic conditions with domestic wastewater as the inoculum, 100% was removed after 7 days incubation @ 25°C; soil, surface water, and aerobic half-lives: 4 weeks-6 months; ground water half-life: 8 weeks-12 months; anaerobic half-life: 16 weeks-24 months; can be detected in water by EPA method 612: methylene chloride extraction followed by concentration, gas chromatography plus electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (rainbow trout exposed to 0.10 ng/L and 3.4 ng/L): 5,800 and 17,000, respectively; no bioaccumulation from a sample lake in an incomplete food chain; can bioaccumulate in fish and shellfish; the concentration found in fish tissues is expected to be much higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** solvent for elastomers; heat transfer fluid; wash liquor for removing higher hydrocarbons; pesticide (fumigant); lubricant; isolating agent for transformers

**TOXICITY:** Fish: goldfish: renewal bioassay: 96 hr TLm: 0.09 mg/L @ 17.5°C; guppy (*Poecilia reticulata*): 14 d LC50: 0.4 ppm; fathead minnow: LC50: 0.09 mg/L/96hr; guppy (*Poecilia reticulata*): LC50: 0.4 ppm/14 days

**EXPOSURE ROUTES:** primarily inhalation; skin adsorption; ingestion; disposal following industrial uses; drinking contaminated water and eating contaminated fish or foods

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 90 µg/L based on acute toxicity, 9.3 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** 32 µg/L based on acute toxicity; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 4.47 µg/L; USSR MAC: 0.01 mg/L in water bodies used for domestic purposes; Kansas and Minnesota guidelines in drinking water: 4.5 µg/L

**PROBABLE FATE:** **photolysis:** adsorption of sunlight is too weak to make photolysis important, photooxidation half-life in air: 119.4 days-3.3 yrs; **oxidation:** expected to be unimportant because of a lack of information; **hydrolysis:** expected to be unimportant because of a lack of information; **volatilization:** low vapor pressure precludes volatilization as an important transport process, expected to evaporate quickly; **sorption:** adsorbed by organic materials very strongly; **biological processes:** bioaccumulation occurs in some aquatic organisms, no information on biodegradation

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 2

**KEY REFERENCES:** 11; 19; 21; 23; 25; 26; 27; 28; 30; 31

## HEXACHLOROCYCLOPENTADIENE (C<sub>5</sub>Cl<sub>16</sub>, 272.29)

**CAS/DOT IDENTIFICATION #:** 77-47-4/UN 2646

**SYNONYMS:** C-56, graphlox, HCCPD, PCL, 1,2,3,4,5,5-hexachloro-1,3-cyclopentadiene, perchloro-1,3-cyclopentadiene, perchlorocyclopentadiene, others

**PHYSICAL PROPERTIES:** pale, yellow liquid; pungent odor; MP (-10°C @ 753 mmHg); BP (239°C @ 653 mmHg); DN (1.717 g/cm<sup>3</sup> @15°C); SG (1.702); ST (47 dynes/cm); VP (0.13 psia @ 20°C); VD (9.42); solubility (0.0002%); OT (0.03 ppm); HV (42 cal/g); Log Kow (5.04); H (16.4x10<sup>-3</sup> atm-m<sup>3</sup>/mole); refractive index (1.5658 @ 20°C)

**CHEMICAL PROPERTIES:** noncombustible; incompatible with strong oxidizing agents; decomposes when exposed to moist air or water

**BIOLOGICAL PROPERTIES:** not persistent in the environment; expected to be generally mobile if released to soil; soil and aerobic half-lives: 7 days-4 weeks; surface water half-life: 1 minute-7.2 days; ground water half-life: 7.2 days-8 weeks; anaerobic half-life: 28 days-16 weeks; can be detected in water by EPA Method 612: methylene chloride extraction followed by concentration, gas chromatography with electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (fathead minnows): <11 (30 day exposure); the concentration found in fish tissues is expected to be much higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** intermediate for dyes, pesticides, fungicides, pharmaceuticals, flame retardant materials

**TOXICITY:** fathead minnows: larvae: 96 hr LC50: 7.0 µg/L (flow through test), larval and early stages: 30 d LC50: 6.7 µg/L (flow through test)

**EXPOSURE ROUTES:** inhalation of vapors; adsorption through the skin; ingestion; emissions and effluent discharges from manufacture, use, and application as an intermediate and pesticide; emissions from combustion of chlorinated wastes; ingestion of contaminated drinking water or fish; people living near hazardous waste disposal sites

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 7 µg/L based on acute toxicity, 5.2 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** 7.0 µg/L based on acute toxicity; **Criterion to protect human health:** 1.0 µg/L based on organoleptic considerations; 206 µg/L based on public health considerations; USSR MAC: 0.001 mg/L in water bodies used for domestic purposes; Kansas drinking water guideline: 206 µg/L

**PROBABLE FATE:** **photolysis:** near-surface photolysis is an important process, aqueous photolytic half-life: 1-10.7 min., photooxidation half-life in air: 1-8.9 hrs, in the air, direct photolysis is expected to be the major removal mechanism, reaction with photochemically produced hydroxyl radicals is not expected to be important; **oxidation:** lack of data probably indicates unimportance; **hydrolysis:** acid-catalyzed hydrolysis to tetrachlorocyclopentadienone could occur only if HCCPD is adsorbed onto clay surfaces, subject to chemical hydrolysis in moist soil; first-order hydrolytic half-life: 7.2 days, chemical hydrolysis is an important fate process in unlit, turbid water, with half-lives from several hrs to 2-3 weeks in waters of 20-30°C; **volatilization:** appears to be important in flowing waters, volatilization from soil surfaces is expected to be dependent upon organic carbon content, volatilization half-life from a model river and a model pond with or without adsorption: 5 hrs, 37 days, and hrs respectively; **sorption:** adsorption onto organic matter may be important, adsorbs extensively to suspended solids and sediments, but does not affect the rate of hydrolysis; **biological processes:** bioaccumulation in many organisms, weak biodegradation to tetrachlorocyclopentadiene hydrate, subject to biodegradation in moist soil

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 4

**KEY REFERENCES:** 19; 21; 23; 25; 26; 27; 28; 30

## HEXACHLOROETHANE (C<sub>2</sub>Cl<sub>6</sub>, 236.72)

**CAS/DOT IDENTIFICATION #:** 67-72-1/UN 9037

**SYNONYMS:** alvotane, alvolthane, carbon hexachloride, distokal, distopan, distopin, egitol, ethane hexachloride, ethylene hexachloride, falkitol, fasciolin, mottenhexe, perchloroethane, phenohep, HCE

**PHYSICAL PROPERTIES:** white, crystalline powder; camphor-like odor; not soluble in water; soluble in alcohol, ether, hot fluoric acid, benzene, and chloroform; MP (186°C); BP (sublimes @ 185°C); DN (2.091 g/cm<sup>3</sup> @ 20°C); SG (2.091); VP (1 mmHg @ 33°C); VD (8.16); solubility in water (50 mg/L @ 22°C); OT (0.010 ppm); Log Kow (3.34); H (9.85x10<sup>-3</sup> atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** nonflammable; carcinogenic; reacts with metals

**BIOLOGICAL PROPERTIES:** may persist for greater than 2 yrs if released to soil and could potentially contaminate ground water; not expected to degrade in the troposphere; diffuses slowly into the stratosphere (half-life of about 30 yrs) where it is expected to photodegrade; long range transport is expected; soil, surface water, and aerobic half-life: 4 weeks-16 months; ground water half-life: 8 weeks-12 months; anaerobic half-life: 16 weeks-24 months; can be detected in water by EPA Method 612: methylene chloride extraction followed by concentration, gas chromatography with electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** organic synthesis; retarding agent in fermentation; rubber accelerator; pyrotechnics and smoke devices; solvent; epoxides; insecticides; veterinary antihelmintic to destroy tapeworms; ignition suppressant; lube oils additive; pesticide; intermediate for pharmaceuticals, moth repellent; metal and alloy production; polymer additive

**TOXICITY:** data is not available

**EXPOSURE ROUTES:** inhalation of contaminated air; skin adsorption; eye contact; ingestion of contaminated drinking water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 118,000 µg/L based on acute toxicity, 20,000 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** 113,000 µg/L based on acute toxicity; **Criterion to protect human health:** 9.4 µg/L to keep the lifetime cancer risk below 10<sup>-5</sup>; USSR MAC: 0.01 mg/L in water bodies used for domestic purposes; Kansas and Minnesota have set guidelines in drinking water as 1.9 µg/L and 24.6 µg/L respectively

**PROBABLE FATE:** **photolysis:** photodissociation in stratosphere may be important, not important in aquatic environment, photooxidation half-life in air: >7.3->73 yrs; photooxidation by U.V. in aqueous medium @ 90-95°C: time for the formation of CO<sub>2</sub> (% theoretical): 25%: 25.2 hr, 50%: 93.7 hr, 75%: 172.0 hr; **oxidation:** not an important process; **hydrolysis:** probably unimportant; **volatilization:** some volatilization occurs, importance as a fate mechanism is unknown, measured half-life for evaporation from 1 ppm aqueous solution @ 25°C, still air, and an average depth of 6.5 cm: 40.7 min, should volatilize slowly from dry soil surfaces, if released to water, volatilization appears to be the most dominant removal mechanism (half-life 15 hrs from a model river); **sorption:** no data available, moderate to slight adsorption to suspended solids and sediments may occur; **biological processes:** high Log Kow indicates possibility of bioaccumulation

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption* (based on synthetic wastewater), 90, 0.079

**KEY REFERENCES:** 19; 21; 23; 25; 26; 27; 30

**INDENO (1,2,3-cd) PYRENE (C<sub>22</sub>H<sub>12</sub>, 276.34)**

**CAS/DOT IDENTIFICATION #:** 193-39-5/UN not available

**SYNONYMS:** 2,3-o-phenylenepyrene, IP, o-phenylenepyrene

**PHYSICAL PROPERTIES:** yellow plates or needles from light petroleum; solutions shows greenish, yellow fluorescence; MP (162-164°C); BP (536°C); VP (1.0x10<sup>-1</sup> mmHg); solubility in water (0.062 mg/L); Log Kow (7.66)

**CHEMICAL PROPERTIES:** very stable under normal laboratory conditions

**BIOLOGICAL PROPERTIES:** Koc: 20,146; not expected to leach; persistent in the aquatic environment and concentrates in sediments; will probably degrade very slowly; soil and aerobic half-lives: 1.64-2.0 yrs; surface water half-life: 125-250 days; ground water half-life: 3.29-4.0 yrs; anaerobic half-life: 6.58-8.0 yrs; can be detected in water by EPA Method 610: methylene chloride extraction followed by high performance liquid chromatography (HPLC) with fluorescence or UV detection or gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** high potential for bioconcentration in most aquatic organisms; may not bioconcentrate in fish since fish have microsomal oxidase; BCF (estimated): 59,407 indicating a strong potential for bioaccumulation

**ORIGIN/INDUSTRY SOURCES/USES:** research chemical; not used commercially in the USA; formed in most combustion or elevated temperature processes that involve compounds containing carbon and hydrogen; coal, wood and gasoline combustion; municipal waste incineration

**TOXICITY:** data not available

**EXPOSURE ROUTES:** internal combustion engine exhausts, cigarette smoke condensate; soot; coal tar pitch; ingestion; inhalation; skin contact; coke oven emissions; rain; drinking water; ground water; marine and freshwater sediments; automobile exhaust; powdered milk; infant formula; seafoods

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; WHO: 0.2 µg/L drinking water standard for all polycyclic aromatic hydrocarbons; lifetime cancer risk of 1 in 100,000: 0.028 µg/L; Kansas set a drinking water standard of 0.029 µg/L

**PROBABLE FATE:** **photolysis:** insufficient data, but probably only a small portion of the compound would be available in dissolved form for photolysis, atmospheric and aqueous photolytic half-life: 125-250 days, photooxidation half-life in air: 0.629-6.29 hrs, reaction with photochemically produced hydroxyl radicals, has an estimated half-life of about 20 hrs; **oxidation:** rapid oxidation by chlorine and/or ozone may compete for dissolved compound; **hydrolysis:** not an important process; **volatilization:** probably too slow to be important; **sorption:** very strong adsorption onto suspended solids should be the dominant transport process; **biological**

**processes:** bioaccumulation is short-term, metabolization and microbial biodegradation are the principal fates

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 40; *Activated sludge*, >99, <0.02

**KEY REFERENCES:** 11; 21; 23; 25; 26; 28; 30

## ISOPHORONE (C<sub>9</sub>H<sub>14</sub>O, 138.2)

**CAS/DOT IDENTIFICATION #:** 78-59-1/UN not available

**SYNONYMS:** isoacetophorone, isoforon, izoforon, 1,1,3-trimethyl-3-cyclohexane-5-one-1-one, 3,3,5-trimethyl-5-3,3,5-trimethyl-5-cyclohexen-1-one, trimethylcyclohexanone

**PHYSICAL PROPERTIES:** water-white liquid with a camphor-like odor; soluble in vinyl resins, cellulose ester, ether, and acetone alcohol; not soluble in water; MP (-8°C); BP (213-214°C @ 760 mmHg); DN (0.923 g/L @ -8°C); SG (0.92); VP (0.2 mmHg @ 20°C); VD (4.77); VS (2.62 cP @ 20°C); solubility in water (12,000 mg/L); OT (0.2 ppm); Log Kow (1.67)

**CHEMICAL PROPERTIES:** reacts with oxidizing materials, strong alkalies, and amines; combustible; FP (84°C); AT (864°F); LFL/UFL (0.8%, 3.8%)

**BIOLOGICAL PROPERTIES:** biodegradation products include: 3,5,5-trimethyl-2-cyclohexene-1,4-dione, 3,5,5-trimethylcyclohexane-1,4-dione, (S)-4-hydroxy-3,5,5-trimethyl-2-cyclohexen-1-one, and 3-hydroxymethyl-5,5-dimethyl-2-cyclohexen-1-one; if released to air, is expected to exist primarily in the vapor phase; contamination of ground water through leaching from soil is potentially possible; soil, surface water, and aerobic half-lives: 7 days-4 weeks; ground water half-life: 14 days-8 weeks; anaerobic half-life: 28 days-16 weeks; can be detected in water by EPA Method 609: methylene chloride extraction followed by exchange to toluene, gas chromatography with flame ionization detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** not expected to bioaccumulate significantly in aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of pesticides; polyvinyl and nitrocellulose resins; in solvent mixtures for finishes; solvent in lacquers, printing inks, paints, adhesives; metals; gasoline

**TOXICITY:** data not available

**EXPOSURE ROUTES:** inhalation; ingestion of contaminated drinking water; skin and eye contact; skin adsorption; coal-fired power plants; exposure to ink, paints, lacquers, and adhesives; metal coating industries

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 117,000  $\mu\text{g/L}$  based on acute toxicity; **Criterion to protect saltwater aquatic life:** 12,900  $\mu\text{g/L}$  based on acute toxicity; **Criterion to protect human health:** 5,200  $\mu\text{g/L}$ ; Kansas has set a drinking water guideline of 5,200  $\mu\text{g/L}$

**PROBABLE FATE:** *photolysis:* photooxidation half-life in air: 0.411-3.13 hrs; not expected to photolyze significantly, reaction with photochemically produced hydroxyl radicals is of minor importance, with a half-life of 32 min.; *oxidation:* not expected to oxidize; *hydrolysis:* not expected to undergo hydrolysis; *volatilization:* if released to soil, will be removed partially by volatilization, with a half-life of 7.5 days from a model river; *sorption:* not expected to sorb significantly to solids and sediments in water; *biological processes:* if released to soil, will be partially removed by biodegradation

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 6; *Gas flotation with chemical addition (calcium chloride, polymer)*, >95, not detected; *Sedimentation*, 49->97, <23; *Aerated lagoons*, 33, 2; *Activated sludge*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption*, 97, 30000; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 160; *continuous activated sludge biological treatment simulator:* 98% removal; may be removed by *wet or dry deposition* when emitted to air in particulate form

**KEY REFERENCES:** 19; 21; 23; 25; 26; 30

## LEAD (Pb, 207.2)

**CAS/DOT IDENTIFICATION #:** 7439-92-1/UN not available

**SYNONYMS:** Pigment metal 4, lead flake, olow

**PHYSICAL PROPERTIES:** blueish-gray, soft metal; pure lead is insoluble in water; poor electrical conductor; good sound and vibration adsorber; MP (327.43°C); BP (1740°C); DN (11.34  $\text{g/cm}^3$  @ 20°C); SG (11.3); VP (1.0 mmHg @ 980°C); VS (3.2 cP @ 327.4°C); HV (206 cal/g @ 1760°C)

**CHEMICAL PROPERTIES:** noncombustible; reacts with hot concentrated nitric acid; reacts with boiling hydrochloric or sulfuric acid; attacked by pure water; attacked by weak organic acids in the presence of  $\text{O}_2$ ; resistant to tap water, hydrofluoric acid, brine, and solvents

**BIOLOGICAL PROPERTIES:** the biological half-life for lead in the bones of humans is 10 yrs; can be detected in water by atomic adsorption or by colorimetric analysis or by inductively coupled plasma optical emission spectrometry, dissolved lead by 0.45 micron filtration prior to such analysis

**BIOACCUMULATION:** adsorbed by fresh water field crab through the gills, and distributed by the haemolymph to the hepatopancreas, muscle, and exoskeleton; haemolymph contained the highest amount of lead followed by gill, hepatopancreas, muscle, and exoskeleton; bioaccumulation over the course of the study showed a high degree of organ speciation; the concentration found in fish tissues is expected to be much higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** batteries; metal products; solder; pipes; gas-line additive; sheet lead; ammunition; cable covering; roofing; devices to shield X-rays; tank linings; pigments for paints; ceramics; plastics; electronic devices; building construction; foil

**TOXICITY:** Japanese quail (*Coturnix japonica*): LC50, 14 days oral 5000 ppm; @ 1000, 2236, and 5000 onset of toxic signs @ 7, 7, and 7 days, remitted at 11, 11, and 12 days, respectively, no mortality observed

**EXPOSURE ROUTES:** leaded gasoline combustion; combustion of solid waste, coal, and oils; emissions from iron and steel production; lead smelters; tobacco smoke; food and soil; lead-based paints; flaking paint; paint chips; weathered paint powder; drinking water; pipes, solder, and fixtures; lead smelting and refining industries; steel and iron factories; gasoline stations; battery manufacturing plants

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:**  $\exp[2.35 \ln(\text{hardness}) - 9.48]$ , never to exceed  $\exp[1.22 \ln(\text{hardness}) - 0.47]$ ; **Criterion to protect saltwater aquatic life:** 668  $\mu\text{g/L}$  based on acute toxicity, 25  $\mu\text{g/L}$  based on chronic toxicity; **Criterion to protect human health:** 50  $\mu\text{g/L}$ ; worldwide organizations have set standards in drinking water as follows, in mg/L: Argentina: 0.01, Czechoslovakia: 0.05, Germany: 0.04, Japan: 0.10, Mexico: 0.05, USSR: 0.03, WHO: 0.10; Maine and Minnesota have set a guideline in drinking water at 20  $\mu\text{g/L}$

**PROBABLE FATE:** **photolysis:** not important; **oxidation:** Pb (IV) readily reduces to Pb (II), solubility control by  $\text{PbSO}_4$  @ low pH and by  $\text{PbCO}_3$  @ high pH; **hydrolysis:** not important @ pH < 11.5; **volatilization:** importance of volatilization of  $(\text{CH}_3)_4\text{Pb}$  unknown in natural condition; **sorption:** Pb removed to sediments effectively by inorganic solids, hydrous iron oxides and crystalline structures; **biological processes:** bioaccumulation by aquatic organisms and biomethylation by microbes

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 150; *Gas flotation*, 49-82, 110; *Gas flotation with chemical addition (calcium chloride, polymer)*, 97-98, 150; *Gas flotation with chemical addition (polymer)*, 15->29, <400; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, 36->99, 140; *Sedimentation*, 69->99, 420; *Sedimentation with chemical addition (alum, lime)*, 50, <200; *Sedimentation with chemical addition (lime, polymer)*, >72-98, 210; *Sedimentation with chemical addition (sulfide)*, >93-96, 100; *Sedimentation with chemical addition (polymer)*, >52-97, 77; *Sedimentation with chemical addition (alum, polymer)*, >74->96, <320; *Sedimentation with chemical addition (alum)*, 6-18, 120; *Sedimentation with chemical addition (lime)*, 60-99, 51; *Tertiary polishing lagoons*, >72, <10; *Aerated lagoons*, 86-93, <50; *Trickling Filters*, 0, negative removal; *Ultrafiltration*, >74->95, 1000; *Ozonation*, >29, <22; *Ion exchange*, 99, 10; *Activated sludge*, 49-99, 40; *Granular activated carbon adsorption*, 14->72, 46; *Reverse osmosis*, 31->99, 210

**KEY REFERENCES:** 11; 19; 21; 23; 27

## MERCURY (Hg, 200.59)

**CAS/DOT IDENTIFICATION #:** 7439-97-6/UN 2809

**SYNONYMS:** colloidal mercury, quick silver

**PHYSICAL PROPERTIES:** silver-white metal; mobile liquid; insoluble in hydrochloric acid; soluble in sulfuric acid upon boiling; insoluble in water, alcohol, and ether; MP (-38.89 C); BP (356.9 C); DN (13.534  $\text{g/cm}^3$  @ 25 C); ST (484 dynes/cm); VP (0.002 mmHg @ 25 C)

**CHEMICAL PROPERTIES:** when heated to boiling point, oxidized to HgO; does not tarnish when exposed to air; combines with sulfur; reacts with ammonia solutions in air to form Hg<sub>2</sub>NOH

**BIOLOGICAL PROPERTIES:** highly persistent in water, with a half-life greater than 200 days

**BIOACCUMULATION:** builds up in the tissues of fish and other organisms; the concentration of mercury (II) and methyl mercury found in fish tissues is expected to be considerably higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** naturally occurring; thermometers; barometers; hydrometers; pressure-sensing devices; batteries; lamps; switches; mercury boilers; extracting gold and silver from ores; electric rectifiers; pharmaceuticals; agricultural chemicals; antifouling paints; industrial processes; refining; lubrication oils; dental amalgams; inorganic mercury; laxatives; skin-lightening creams and soaps; latex paint

**TOXICITY:** high acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** inhalation in occupational settings; dental amalgam fillings; skin adsorption; eye and skin contact; eating contaminated fish or shellfish; breathing vapors from spills, incinerators, and industries that burn mercury-containing fuels; hazardous waste sites above-background levels in air

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** lifetime health advisory: 0.0011 µg/L; guidelines for drinking water set by the EPA: 0.002 µg/L; worldwide organizations have set standards in drinking water as follows, in mg/L; Czechoslovakia: 0.001, Germany: 0.004, Japan: 0.0005, Mexico: 0.005, USSR: 0.0005, USA: 0.002; WHO: 0.001; guidelines in drinking water set by some states: 2 µg/L (Maine), 3 µg/L (Minnesota)

**PROBABLE FATE:** **photolysis:** breakdown of atmospheric dimethyl mercury is of slight importance; **oxidation/reduction:** oxidation of metallic mercury forms ionic mercury (later adsorbed), reduction forms HgS precipitate; **hydrolysis:** not an important process; **volatilization:** metallic Hg, methylated Hg, and adsorbed Hg all volatilizable; **sorption:** Hg is adsorbed by most particles, buried in sediment, and reduced to HgS; **biological processes:** bioaccumulated by all organisms and readily methylated metabolically

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 1.4; *Gas flotation*, 0, negative removal; *Gas flotation with chemical addition (calcium chloride, polymer)*, >68->90, <0.8; *Gas flotation with chemical addition (alum, polymer)*, 33, 1; *Filtration*, 45-86, 340; *Sedimentation*, 50->99, 6.1; *Sedimentation with chemical addition (alum, lime)*, 71, 2; *Sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Sedimentation with chemical addition (Fe<sup>2+</sup>, lime)*, >30->60, <0.2; *Sedimentation with chemical addition (sulfide)*, >99, 20; *Sedimentation with chemical addition (polymer)*, >62-99, 70; *Sedimentation with chemical addition (BaCl<sub>2</sub>)*, 87, 0.5; *Sedimentation with chemical addition (alum, polymer)*, 71-88, 5200; *Sedimentation with chemical addition (alum)*, >34->62, <76; *Sedimentation with chemical addition (lime)*, 35->96, 1.4; *Aerated lagoons*, >99, 0.1; *Ultrafiltration*, 15-20, 0.6; *Activated sludge*, 30-87, <0.8; *Granular activated carbon adsorption*, 33->99, 1.6; *Reverse osmosis*, 22->60, 0.5; *Powdered activated carbon adsorption*, 0, negative removal

**KEY REFERENCES:** 19; 21; 23; 27; 31

**METHYL BROMIDE (CH<sub>3</sub>Br, 94.95)****CAS/DOT IDENTIFICATION #:** 74-83-9/UN 1062

**SYNONYMS:** bromomethane, brom-o-gas, dawson 100, dowfume, EDCO, embafume, halon 1001, ascobrome, kayafume, MB, MBX, MEBR, metafume, methogas, terr-o-gas 100, zytox, many others

**PHYSICAL PROPERTIES:** colorless, transparent; burning taste; chloroform-like odor; slightly soluble in water; MP (-4°C); BP (4°C); DN (3.3 g/mL @ 20°C); SG (1.732); VS (369.1x10<sup>-6</sup> Pa @ 25°C); ST (22.36x10<sup>-3</sup> N/m); VP (1250 mmHg @ 20°C); VD (3.27); solubility in water (900 mg/L); OT (80 ppm); HV (23.91 kJ/gmol); Log Kow (1.1); refractive index (1.4432 @ -20°C)

**CHEMICAL PROPERTIES:** nonflammable in air but burns in oxygen; will not polymerize; incompatible with aluminum and strong oxidizers; HC (-705.4 kJ/mol); AT (535°C); LEL/UEL (10%, 16%)

**BIOLOGICAL PROPERTIES:** moves quickly into the air when released or when present in soil or water; breaks down slowly in air over several years; breaks down rapidly in soil over a few days; small amounts move from soil into ground water; breaks down in ground water over several months; expected to leach; weak adsorption to soil; soil, surface water, and aerobic half-lives: 7 days-4 weeks; ground water half-life: 14 days-38 days; anaerobic half-life: 28 days-16 weeks; can be determined in water by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** does not build up in animals or plants; bioconcentration is not expected to be significant

**ORIGIN/INDUSTRY SOURCES/USES:** formed naturally from algae and kelp in ocean; fumigant for rats, insects, fungus, weeds, and nematodes; herbicide; wool degreaser; methylating agent; fire extinguishing agent; extracting oils from nuts and seeds; solvent for aniline dyes; refringerant

**TOXICITY:** Fish: *Lepomis macrochirus*: static bioassay in fresh water @ 23°C, mild aeration applied after 24 hr: 14 ppm material added, % survival after 24 hr: 30%, after 48 hr: 0%; 7 ppm material added, after 24 hr: 100% survival, after 96 hr, 90% survival; *Menidia beryllina*: static bioassay in synthetic seawater @ 23°C: mild aeration applied after 24 hr: 14 ppm material added: 0% survival after 24 hr; 7 ppm material added, 80% survival after 96 hr

**EXPOSURE ROUTES:** primarily by inhalation; adsorption through the eyes and skin; ingestion; air; occupational; drinking water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 1.9 µg/L; guidelines in drinking water set by some states: 2.5 µg/L (Arizona), 0.19 µg/L (Kansas)

**PROBABLE FATE:** **photolysis:** volatilized methyl bromide should photodissociate above the ocean layer, probably not significant in aquatic systems, reaction with photochemically produced hydroxyl radicals has a half-life from 0.29-1.6 yrs, direct photolysis is the dominant fate in the stratosphere, but is not expected to be important in the troposphere; **oxidation:** atmospheric photooxidation by hydroxyl radicals releases inorganic bromide which is carried

down by rain, photooxidation half-life in air: 68-680 days; **hydrolysis**: unvolatilized methyl bromide should undergo hydrolysis with a half-life <20 days, first-order hydrolytic half-life: 19.6-38 days; hydrolysis to methanol and bromide ions has a half-life of 20-26.7 days; **volatilization**: rapid volatilization is the dominant transport process, primarily lost by volatilization when released to soil; **sorption**: too slow to compete with volatilization; **biological processes**: not expected to be important

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): data is unavailable

**KEY REFERENCES**: 19; 21; 23; 25; 26; 28; 30; 31

### METHYLENE CHLORIDE ( $\text{CH}_2\text{Cl}_2$ , 84.93)

**CAS/DOT IDENTIFICATION #**: 75-09-2/UN 1593

**SYNONYMS**: dichloromethane, methane dichloride, methylene bichloride

**PHYSICAL PROPERTIES**: clear liquid; slightly sweet odor; slightly soluble in water; MP ( $-97^\circ\text{C}$ ); BP ( $39.8\text{-}40^\circ\text{C}$ ); DN ( $1.325\text{ g/mL}$ ); SG (1.33); ST ( $26.52\text{ dynes/cm}$ ); VS ( $0.43\text{ cP @ }20^\circ\text{C}$ ); VP ( $349\text{ mmHg @ }20^\circ\text{C}$ ); VD (2.93); solubility in water ( $16,700\text{ mg/L @ }25^\circ\text{C}$ ); OT ( $250\text{ ppm}$ ); HV ( $28.06\text{ KJ/gmol}$ ); Log Kow (1.25); H ( $3.19\times 10^{-3}/\text{mole}$ ); refractive index ( $1.4242 @ 20^\circ\text{C}$ )

**CHEMICAL PROPERTIES**: nonflammable; HC ( $-513.9\text{ kJ/mol}$ ); very stable; reacts violently with alkali metals, aluminum, and potassium-butoxide; AT ( $662^\circ\text{C}$ ); LEL/UEL (14%, 22%)

**BIOLOGICAL PROPERTIES**: % degraded under aerobic continuous flow conditions: 94.5%; partially leaches into ground water; soil, surface water, and aerobic half-lives: 7 days-4 weeks; ground water half-life: 14 days-8 weeks; anaerobic half-life: 28 days-16 weeks; can be determined in water by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION**: not expected to bioconcentrate in aquatic organisms or in the food chain; the concentration found in fish tissues is expected to be about the same as the concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES**: used as a solvent in the manufacture of drugs, paint, plastics, cellulose acetate; laboratory solvent; propellant; refrigerant; parts degreaser; degreasing agent for citrus fruit; blowing agents in foams

**TOXICITY**: Bacteria (*Pseudomonas*):  $\text{LD}_0$ : 1 g/L; Algae (*Scenedesmus*): 125 mg/L; Arthropod (*Daphnia*): 1.25 g/L; Protozoa (*Colpoda*): 1 g/L; threshold concentration of cell multiplication inhibition of the protozoan *Uronema parduczi* Chatton-L-woff:  $>16,000\text{ mg/L}$ ; guppy (*Poecilia reticulata*): 14 d  $\text{LC}_{50}$ : 294 ppm; fathead minnow: 96 hr  $\text{LC}_{50}$  (F): 193 mg/L, 96 hr  $\text{LC}_{50}$  (S): 310 mg/L

**EXPOSURE ROUTES**: primarily by inhalation; adsorption through skin and eyes; ingestion; drinking water; ambient air; occupational or consumer exposure from indoor spray painting or other aerosol uses

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** **Criterion to protect saltwater aquatic life:** **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 1.9 µg/L; USSR MAC: 7.5 mg/L; the following are guidelines in drinking water set by some states: 2 µg/L (New Jersey); 100 µg/L (New Mexico); 4.7 µg/L (Arizona); 25 µg/L (Connecticut); 40 µg/L (California); 48 µg/L (Minnesota and Vermont); 50 µg/L (Kansas); 150 µg/L (Maine)

**PROBABLE FATE:** **photolysis:** photochemical reactions in aqueous media are probably unimportant, slow decomposition in the troposphere in the presence of nitrogen oxides is possible, appreciable photodissociation may occur in stratosphere, photooxidation half-life in air: 19.1-191 days; **oxidation:** probably unimportant, in troposphere, oxidation by hydroxyl radicals to CO<sub>2</sub>, CO, and phosgene is important fate mechanism; **hydrolysis:** not an important fate process, first-order hydrolytic half-life: 704 yrs; **volatilization:** due to high vapor pressure, volatilization to the atmosphere is rapid and is a major transport process; **sorption:** sorption to inorganic and organic materials is not expected to be an important fate mechanism; **biological processes:** bioaccumulation is not expected, biodegradation may be possible but very slow compared with evaporation

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, >42; *Gas flotation with chemical addition (calcium chloride, polymer)*, 2-7, 2000; *Gas flotation with chemical addition (polymer)*, 61, 22; *Gas flotation with chemical addition (alum, polymer)*, 84, 8; *Filtration*, 14-62, 2400; *Sedimentation*, 38-88, 530; *Sedimentation with chemical addition (alum, lime)*, 13, 2000; *Sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Sedimentation with chemical addition (polymer)*, 0, negative removal; *Sedimentation with chemical addition (alum, polymer)*, 56-98, 5600; *Sedimentation with chemical addition (alum)*, >78->99, <40; *Aerated lagoons*, 65-97, 390; *Steam stripping*, 75-87, 160000; *Trickling filters*, 0, negative removal; *Ozonation*, 0, negative removal; *Activated sludge*, 21-99, 95; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Granular activated carbon adsorption*, 31-92, 140; *Powdered activated carbon adsorption* (based on synthetic wastewater), 84, 162; *Reverse osmosis*, 21-64, 5

**KEY REFERENCES:** 19; 21; 23; 25; 26; 27; 30

### N-NITROSO-DI-N-PROPYLAMINE (C<sub>6</sub>H<sub>14</sub>N<sub>2</sub>O, 130.22)

**CAS/DOT IDENTIFICATION #:** 621-64-7/UN not available

**SYNONYMS:** N-nitosodipropylamine, N,N-dipropylnitrosoamine, NDPA

**PHYSICAL PROPERTIES:** yellow liquid; MP (~0°C); BP (206°C); DN (0.9162 g/mL); solubility in water (9,900 mg/L); Log Kow (1.31)

**CHEMICAL PROPERTIES:** FP (210°F)

**BIOLOGICAL PROPERTIES:** dissipation of C14 from soil: 571 µg NDPA/M2 was applied to soil, after 2 hrs, only 52.6% was still present; approximately 92% of the radioactivity was extractable with methanol, after 8 and 49 days, the soil radioactivity declined to 16.9% and 11% respectively; at 8 days, only 16% of the soil radioactivity was extractable with methanol; may leach into ground water; soil, and aerobic half-lives: 21 days-6 months; surface water half-life: 0.17-1 hr; ground water half-life: 42 days-12 months; anaerobic half-life: 84 days-24 months

**BIOACCUMULATION:** the concentration found in fish tissues is expected to be about the same as the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** impurity in dinitroaniline-based weed killers; manufacture of some rubber products; research chemical

**TOXICITY:** insufficient data

**EXPOSURE ROUTES:** inhalation; consumption of contaminated food and water; alcoholic beverages; waste disposal sites; wastewater; secondary effluent from textile plants; soils treated with the herbicide; cooked fish

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** no criteria set; **Criterion to protect saltwater aquatic life:** no criteria set; **Criterion to protect human health:** no criteria set

**PROBABLE FATE:** *photolysis:* photolysis is slow but is the principal fate of the compound, atmospheric and aqueous photolytic half-life: 0.17-1 hrs, will quickly photolyze in the atmosphere, estimated half-life with hydroxyl radicals: 4.03 days; *oxidation:* not important, photooxidation half-life in air: 2.66-26.6 hrs; *hydrolysis:* not important; *volatilization:* no loss to volatilization is reported, will rapidly volatilize if released to the surface of soils; *sorption:* moderate adsorption by organic matter is possible, not expected to sorb strongly to organic matter if released to soil, if released to water, there is a slight tendency; *biological processes:* not important

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Activate sludge*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), 50, 2500; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 260

**KEY REFERENCES:** 21; 23; 25; 26; 27; 30

## **N-NITROSODIMETHYLAMINE ((CH<sub>3</sub>)<sub>2</sub>NNO, 74.10)**

**CAS/DOT IDENTIFICATION #:** 62-75-9/UN 2810

**SYNONYMS:** dimethylnitrosamine, N,N-dimethylnitrosamine, dimethylnitrosoamine, DMN, DMNA, N-Methyl-n-nitrosomethanamine, NDMA, nitrosodimethylamine

**PHYSICAL PROPERTIES:** yellow, oily liquid; faint characteristic odor; very soluble in water, alcohol, and ether; miscible with methylene chloride; BP (153°C); DN (1.0048 g/mL @ 20°C); SG (1.005); VP (2.7 mmHg @ 20°C); VD (2.56); Log Kow (-0.57); refractive index (1.4374 @ 18°C)

**CHEMICAL PROPERTIES:** stable; oxidized to nitramine; photochemically reactive; incompatible with strong oxidizers and strong bases; incompatible with hydrogen bromide in acetic acid

**BIOLOGICAL PROPERTIES:** aerobic degradation in continuous activated sludge unit, 2 ppm concentration reduced to below 0.1 ppm; % biodegradation @ 0.01 mg/L initial concentration, after 3 days in seawater: in daylight: 75%, in dark: 0%; after 15 days in seawater: in daylight: 100%, in dark: 91%; photodegradation is expected to be the most significant degradative process in water; highly mobile in soil and will probably leach extensively; soil and aerobic half-

lives: 21 days-6 months; surface water half-life: 0.5-1 hr; ground water half-life: 42 days-12 months; anaerobic half-life: 84 days-24 months; can be detected in water by EPA Method 607: methylene chloride extraction followed by gas chromatography with nitrogen-phosphorus or reductive Hall detectors, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** not expected to bioconcentrate; the concentration found in fish tissues is expected to be about the same as the concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** used as a solvent in fiber, plastics industry, lubricants; condensers to increase dielectric constant; nematocide; softener for copolymers; formerly in production of rocket fuels; research chemical; chemical intermediate for 1,1-dimethylhydrazine; rubber accelerator; inhibition of nitrification in soil; plasticizer for acrylonitrile polymers; preparation of thiocarbonyl fluoride polymers; antioxidant

**TOXICITY:** fish: rainbow trout: 10 d LD<sub>50</sub> (IP): 1770 mg/kg; has moderate acute toxicity; crayfish male (adult) (*Austropotamobius*): LD<sub>50</sub>: 2250 mg/kg

**EXPOSURE ROUTES:** rubber, tanning, fish processing, dye and surfactant industries; ingestion of food; cured meats and smoked fish; drinking contaminated water; breathing cigarette smoke; contaminated ambient air; percutaneous adsorption

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life: 5850 µg/L based on acute toxicity; Criterion to protect saltwater aquatic life: 3,300,000 µg/L based on acute toxicity; Criterion to protect human health: preferably 0; lifetime cancer risk level of 1 in 100,000: 0.014 µg/L; guidelines in drinking water set by some states: 0.0014 µg/L (Kansas), 0.014 µg/L (Minnesota)

**PROBABLE FATE:** *photolysis:* slow photolysis in aqueous solution, but fast in atmosphere is the principle fate, atmospheric and aqueous photolytic half-lives: 0.5-1 hr; *oxidation:* not an important process, photooxidation half-life in air: 25.4 hrs-10.6 days; *hydrolysis:* does not occur under natural conditions, relatively resistant to hydrolysis, one study reports a half-life of 3 weeks in aerobic soils under laboratory conditions; *volatilization:* too slow to be an important process, if released to the surface of warm, wet soils, it will quickly volatilize; *sorption:* does not occur; *biological processes:* no bioaccumulation, resistant to biodegradation under natural conditions

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Aerated lagoons*, 67, 1; *continuous sewage biological treatment simulator*: 71.4-100% removal

**KEY REFERENCES:** 11; 19; 21; 23; 25; 26; 27; 28; 30

## **N-NITROSODIPHENYLAMINE (C<sub>12</sub>H<sub>10</sub>N<sub>2</sub>O, 198.23)**

**CAS/DOT IDENTIFICATION #:** 86-30-6/UN not available

**SYNONYMS:** N,N-diphenylnitrosoamine, N-nitroso-N-phenylaniline, diphenylnitrosoamine, TJB, Vultrol, NDPA, NDPHA, Delac J, redax

**PHYSICAL PROPERTIES:** orange-brown or yellow solid; MP (66.5°C); DN (1.23 g/cm<sup>3</sup>); SG (1.23); Log Kow (2.57); Log Poct (2.57)

**CHEMICAL PROPERTIES:** probably combustible; may react vigorously with oxidizing materials; may undergo trans-nitrosation reactions with secondary amines

**BIOLOGICAL PROPERTIES:** Koc: 1,200; activated sludge biological treatment simulator: >84% removal; leaks into the ground from waste sites; in air, it attaches to dust particles and can move with the wind; dissolves in water; soil, surface water, and aerobic half-lives: 10-34 days; ground water half-life: 20-68 days; anaerobic half-life: 40-136 days

**BIOACCUMULATION:** BCF (bluegill sunfish): 217; the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** not naturally occurring; industrial compound; not currently used in the USA; used to make rubber products such as tires (former use); used to make chemicals (former use); effective radical scavenger; anti-scouring agent; vulcanization retarder; rubber accelerator

**TOXICITY:** data not available

**EXPOSURE ROUTES:** drinking water near hazardous waste sites; inhalation; dermal exposure; worker inhalation at factories that process rubber

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** USSR MAC: 0.1 mg/L in surface water; guidelines in drinking water set by some states: 71 µg/L (Kansas), 71.1 µg/L (Minnesota)

**PROBABLE FATE:** *photolysis:* photolysis may be an important fate process, reaction with photochemically produced hydroxyl radicals gives an estimated half-life of 7 hrs; *oxidation:* not important, photooxidation half-life in air: 0.7-7 hrs; *hydrolysis:* does not occur under natural conditions; *volatilization:* not important, evaporates slowly to the air, may be a significant transport mechanism from water; *sorption:* probably adsorbed by organic materials but exact fate is unknown, binds to soil and does not move quickly through soil, moderate tendency to partition to sediments, suspended organic matter, and biota when released to water; *biological processes:* potential for bioaccumulation, biodegradation, and biotransformation, but quantized data is unavailable; biodegradation appears to be an important fate process and is affected by the organic carbon level in the soil

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gas flotation with chemical addition (calcium chloride, polymer)*, 66, 620; *Filtration*, 0, negative removal; *Sedimentation*, >77, <10; *Activated sludge*, 84->99, <0.8; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Granular activated carbon adsorption*, >82, <0.07; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 10

**KEY REFERENCES:** 21; 23; 26; 27; 28; 30; 31

## NAPHTHALENE (128.18, C<sub>10</sub>H<sub>8</sub>)

**CAS/DOT IDENTIFICATION #:** 91-20-3/UN 1334 and 2304 (molten)

**SYNONYMS:** albocarbon, camphor tar, mighty 150, mighty RD1, mothballs, moth flakes, white tar, naphthalene molten

**PHYSICAL PROPERTIES:** white crystalline solid or flakes; aromatic odor; very slightly soluble in water; MP (80°C); BP (218°C); DN (1.175 g/cm<sup>3</sup> @ 25°C); SG (1.14); ST (31.8 dynes/cm @ 100°C); VP (0.01 kPa @ 298.15 K); VD (4.42); solubility in water (34.4 mg/L @ 25°C); OT (6.8 ppm in water); HV (43.5 kJ/mol); Log Kow (3.37)

**CHEMICAL PROPERTIES:** combustible; sublimes at room temperature; reacts vigorously with oxidizing materials and chromic anhydride; HC (-9287 cal/g @ 15.5°C); AT (525°C); LFL/UFL (0.9%, 5.9%)

**BIOLOGICAL PROPERTIES:** readily degraded in static biological test using acclimated seed from an activated sludge plant, reduced from 2 ppm to nondetectable during a 7-day test; BOD<sub>5</sub>: 0% ThOD; ThOD: 2.99; T.O.C.: 0.5 mg/L; biodegrades to CO<sub>2</sub>; microbial degradation to CO<sub>2</sub> in seawater @ 12°C in the dark after 24 hr incubation @ 50 µg/L; degradation rate: 0.10 µg/L/day, turnover time: 500 days; after addition of aqueous extract of fuel oil, degradation rate: 1.0-5.0 µg/L/day, turnover time: 10-22 days; soil half-life: 16.6-48 days; surface water half-life: 12 hrs-20 days; ground water half-life: 24 hrs-258 days; aerobic half-life: 12 hrs-20 days; anaerobic half-life: 25 -258 days; can be detected in water by EPA Method 610: methylene chloride extraction followed by high pressure liquid chromatography with fluorescence or UV detection or gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** Fish: BCF (in muscle of Starry flounder): 700 after 1 week exposure, 240 after 2 weeks, 100 after 1 week depuration, 270 after 2 week depuration; BCF (in muscle of Coho salmon): 20 after 2 week exposure, 50 after 3 weeks, 80 after 5 weeks, 40 after 6 weeks; BCF (Atlantic salmon eggs, 168hr): 82.5; moderate bioconcentration, however depuration is rapid when the organism is placed in water free of the pollutant; readily metabolized in fish; more data in referenced sources

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of phthalic and anthranilic acids, naphthols, sulfonic acid, synthetic resins, celluloid, lampblack, smokeless powder, hydronaphthalenes; salicylic acid; indigo; medication; synthetic tanning chemicals; surfactants; insecticide; wood preservative

**TOXICITY:** Algae (*Chlorella vulgaris*) @ 33 ppm: 50% reduction of cell numbers vs. controls, after 1 day incubation @ 20°C; Fish (mosquito fish): 24/96 hr TL<sub>m</sub>: 220/150 mg/L; *Neanthes arenaceodentata*: 96 hr TL<sub>m</sub> in seawater @ 22°C: 3.8 ppm (initial concentration in static assay); more data in referenced sources

**EXPOSURE ROUTES:** use of mothballs; during manufacture and use; coal-tar production; wood preserving; tanning; ink and dye production; burning of coal and oil; tobacco smoke; inhalation; ingestion; skin and eye contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 2300 µg/L based on acute toxicity, 620 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** 2350 µg/L based on acute toxicity; **Criterion to protect human health:** USSR-UNEP/IRPTC MAC: 0.004 mg/L in water bodies used for fishery purposes; Kansas set a drinking water guideline of 143 µg/L

**PROBABLE FATE:** **photolysis:** relatively high solubility could make photooxidation an important fate, data inconclusive, atmospheric and photolytic half-life: 71-550 days; **oxidation:** chlorine and/or ozone in sufficient quantities may oxidize naphthalene, photooxidation half-life in air: 2.96-29.6 hrs; **hydrolysis:** not an important process; **volatilization:** could be very important but the rate is uncertain, half-life in water @ 25°C and 1 m depth: 7.15 hr, based on an

evaporation rate of 0.096 m/hr; **sorption**: relatively low partition coefficient makes adsorption less dominant but sorption is still a competitive transport process, in estuarine waters: @ 30µg/L, 0.7% is adsorbed on particles after 3 hr; **biological processes**: short-term bioaccumulation, biodegradation and metabolization are the ultimate fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 410; *Gas flotation*, ~18-36, ~380; *Gas flotation with chemical addition (calcium chloride, polymer)*, 54-82, 700; *Gas flotation with chemical addition (polymer)*, >65->96, --; *Gas flotation with chemical addition (alum, polymer)*, 52, 11; *Filtration*, >76-86, <5.8; *Sedimentation*, >50->98, <22; *Sedimentation with chemical addition (alum, lime)*, 70, 16; *Sedimentation with chemical addition (lime, polymer)*, 49-98, 6.5; *Tertiary polishing lagoons*, >82, <10; *Aerated lagoons*, >28->58, <5.5; *Trickling filters*, 0, negative removal; *Activated sludge*, 66->99, 17; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Powdered activated carbon adsorption*, >96, <10; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 120

**KEY REFERENCES**: 11; 19; 21; 23; 25; 26

## **NICKEL (Ni, 58.71)**

**CAS/DOT IDENTIFICATION #**: 7440-02-0/UN 2881 1378, 2811

**SYNONYMS**: alcino, nickel 200, nickel 201, nickel 205, nickel 270; nickel sponge; carbonyl nickel powder; Raney nickel

**PHYSICAL PROPERTIES**: silver-white; malleable; insoluble in water; MP (1455°C); BP (2730°C); DN (8.9 g/cm<sup>3</sup>); SG (8.908); VP (1 mmHg @ 1810°C)

**CHEMICAL PROPERTIES**: incompatible with strong acids, sulfur, Ni(NO<sub>3</sub>)<sub>2</sub>, wood and other combustibles; reacts violently with titanium, ammonium nitrate, potassium perchlorate, potassium, performic acid, fluorine, selenium, sulfur, and sulfur compounds, hydrazine, ammonia, and hydrazoic acid

**BIOLOGICAL PROPERTIES**: particles in the air settle to the ground or are taken out in rain; attaches to particles that contain iron or manganese and is therefore found with soil and sediments; highly persistent in water, with a half-life > 200 days; can be detected in water by atomic adsorption or by colorimetric determination or by inductively coupled plasma optical emission spectrometry, dissolved nickel by 0.45 micron filtration prior to such analysis

**BIOACCUMULATION**: does not appear to collect in fish, plants, or other animals used for food; the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES**: metal coins; jewelry; valves; heat exchangers; batteries; textile dyes; spark plugs; machinery parts; stainless steel; nickel plating; catalysts; nickel-chrome resistance wires; to color ceramics

**TOXICITY**: the softer the water, the higher the toxicity to aquatic organisms; high acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** inhalation; ingestion; adsorption through skin; discharges from electroplating and smelting industries; weathering of rocks; emissions from burning coal and fossil fuels

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:**  $\exp [0.76 \ln(\text{hardness}) + 1.06]/24$  hr avg., not to exceed  $\exp [0.76 \ln(\text{hardness}) + 4.02]$  any time; **Criterion to protect saltwater aquatic life:** 7.1  $\mu\text{g/L}/24$  hr avg., not to exceed 140  $\mu\text{g/L}$  any time; **Criterion to protect human health:** 13.4  $\mu\text{g/L}$ ; lifetime health advisory: 150  $\mu\text{g/L}$ ; Mexico has set a limit in estuaries of 0.1 mg/L and 0.008 mg/L in coastal waters; limits in surface water and drinking water of 0.1 mg/L and 0.05 mg/L have been set by Czechoslovakia; guidelines in drinking water set by some states: 150  $\mu\text{g/L}$  (Minnesota), 1000  $\mu\text{g/L}$  (Kansas)

**PROBABLE FATE:** **photolysis:** not important; **oxidation:** under reducing conditions with sulfur, NiS is formed, otherwise is unimportant; **hydrolysis:** hydrolysis under natural conditions removes no nickel from solution; **volatilization:** not important; **sorption:** Ni coprecipitates with hydrous metal oxides, and to a lesser degree is adsorbed by organic matter and incorporated in crystalline minerals; **biological processes:** slightly bioaccumulated, no biotransformation noted

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 69; *Gas flotation*, 0, negative removal; *Gas flotation with chemical addition (calcium chloride, polymer)*, >65->94, <73; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Gas flotation with chemical addition (alum, polymer)*, 41, 270; *Filtration*, 31->99, 64; *Sedimentation*, 59->99, <180; *Sedimentation with chemical addition (alum, lime)*, >83, <1; *Sedimentation with chemical addition (lime, polymer)*, 86-96, 240; *Sedimentation with chemical addition (sulfide)*, >88-96, 860; *Sedimentation with chemical addition (polymer)*, 35, 43; *Sedimentation with chemical addition (alum, polymer)*, 35->97, 17000; *Sedimentation with chemical addition (alum)*, >27->56, <36; *Sedimentation with chemical addition (lime)*, 40-99, 540; *Aerated lagoons*, 17-50, 34; *Ultrafiltration*, >32, <500; *Ozonation*, 0, negative removal; *Ion exchange*, >99, <10; *Activated sludge*, 29-92, 78; *Granular activated carbon adsorption*, 17-68, 110; *Powdered activated carbon adsorption (with activated sludge)*, 19->58, <14; *Reverse osmosis*, 46->98, 66

**KEY REFERENCES:** 19; 21; 23; 27; 28; 31

## NITROBENZENE (C<sub>6</sub>H<sub>5</sub>NO<sub>2</sub>, 123.12)

**CAS/DOT IDENTIFICATION #:** 98-95-3/UN 1662

**SYNONYMS:** essence of mirbane, mirbane oil, nitrobenzol, oil of bitter almonds

**PHYSICAL PROPERTIES:** greenish-yellow crystals or yellow, oily liquid; volatile oil almond odor; pungent, shoe polish smell; MP (5-6°C); BP (210-211°C); DN (1.203 g/cm<sup>3</sup> @ 20°C); SG (1.2); ST (43.9 dynes/cm @ 20°C); VP (0.04 kPa @ 298K); VD (4.3); VS (1.863 mPa-s @ 298K); OT (1.46x10<sup>-2</sup> mg/L); solubility in water (1.780 ppm); HV (55.01 kJ/mol); Log Kow (1.85); H (2.40x10<sup>-5</sup> atm-m<sup>3</sup>/mole); refractive index (1.5529 @ 20°C)

**CHEMICAL PROPERTIES:** combustible liquid; sublimes at room temperature; incompatible with strong oxidizing agents, strong reducing agents, strong bases, aluminum chloride and phenol, aniline, glycerin, nitric acid, nitrogen tetroxide, silver perchlorate; HC (-5.791 cal/g @ 25°C); FP (89°C); AT (481°C); LFL/UFL (1.8%, 40%)

**BIOLOGICAL PROPERTIES:** 98% removal (measured as COD removal) obtained @ 20°C in activated sludge @ a rate of 14 mg COD/g dry inoculum/hr; ThOD: 1.95; inhibition of degradation of glucose by *Pseudomonas fluorescens* @ 30 mg/L; inhibition of degradation of glucose by *E. coli* @ 600 mg/L; decomposition by a soil microfla in >64 days; will leach into soil if released to land; soil, surface water, and aerobic half-lives: 13.4 days-6.6 months; ground water half-life: 2 days-13 months; anaerobic half-life: 2 days-13 months; can be detected in water by EPA Method 609: methylene chloride extraction followed by exchange to toluene, gas chromatography with flame ionization detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** Log BCF (fathead minnows): 1.18; Log BCF (fish): 0.78; Log BCF (green algae): 1.38; the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of aniline, cellulose esters, cellulose acetate; metal polishes; soaps; shoe polishes; refining lubricating oils; pyroxylin compound; preservative in spray paints; perfumes; benzidine; dyes; pesticides; rubber chemicals; pharmaceuticals (acetaminophen)

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 7 mg/L, algae (*Microcystis aeruginosa*): 1.9 mg/L, green algae (*Scenedesmus quadricauda*): 33 mg/L, protozoa (*Entosiphon sulcatum*): 1.9 mg/L; protozoa (*Uronema parduczi Chatton-L-woff*): 15 mg/L; Bacteria (*E.coli*): LD<sub>0</sub>: 600 mg/L; Fish (*Vairon* (F)): distilled water: TLm (6 hr): 20-24 mg/L, hard water: TLm (6 hr): 90-100 mg/L; Algae (*Scenedesmus*): LD<sub>0</sub>: 40 mg/L; Arthropoda (*Daphnia*): LD<sub>0</sub>: 28 mg/L

**EXPOSURE ROUTES:** factories that produce or use it; near waste sites

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 27000 µg/L based on acute toxicity; **Criterion to protect saltwater aquatic life:** 6680 µg/L based on acute toxicity; **Criterion to protect human health:** 30µg/L based on organoleptic considerations, 19800 µg/L based on toxicity considerations; USSR MAC: 0.2 mg/L in water bodies used for domestic purposes; guidelines in drinking water set by some states: 5 µg/L (Kansas), 1.4 µg/L (Maine)

**PROBABLE FATE:** **photolysis:** photoreduction could occur if nitrobenzene is adsorbed onto humus particles, atmospheric and aqueous photolytic half-life: 67-200 days; **oxidation:** only important as method of destroying photoreduction products, photooxidation half-life in water: 125 days-22 yrs, photooxidation half-life in air: 0.544-5.44 hrs; **hydrolysis:** not important; **volatilization:** not fast enough to be important, if released to water, some volatilization is expected; **sorption:** adsorbed by humus and probably by clay; **biological processes:** no bioaccumulation of any significance, biodegradation is relatively slow

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Sedimentation*, >52, <10; *Sedimentation with chemical addition (alum)*, 68, 35; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Aerated lagoons*, 0, negative removal; *Granular activated carbon adsorption*, >67->99, <11; *Powdered activated carbon adsorption*, 79, 67000; *Powdered activated carbon adsorption* (based on synthetic wastewater), 100, 0.9; *Continuous activated sludge biological treatment simulators:* 76-97.8% removal

**KEY REFERENCES:** 11; 19; 21; 23; 25; 26; 27; 28; 30

**2-NITROPHENOL (C<sub>6</sub>H<sub>5</sub>NO<sub>3</sub>, 139.11)**

CAS/DOT IDENTIFICATION #: 88-75-5/UN 1663

SYNONYMS: o-nitrophenol, 2-hydroxy-nitrobenzene; 2-Hydroxynitrobenzene, ONP

**PHYSICAL PROPERTIES:** light yellow needles or prisms; aromatic odor; highly soluble in water; very soluble in chloroform, pyrimidine, ether, and benzene; soluble in alkali, toluene, and carbon disulfide; MP (45°C); BP (214°C); SG (1.657 @20°C); VP (20 mmHg @105°C); solubility in water (2,100 mg/L @ 20°C); Log Kow (1.76); H (3.5x10<sup>-6</sup> atm<sup>3</sup>/mole); pKa (7.230); refractive index (1.5723 @ 50°C)

**CHEMICAL PROPERTIES:** reacts violently with potassium hydroxide ; FP (215°F)

**BIOLOGICAL PROPERTIES:** 97% removal @ 20°C in activated sludge at a rate of 14 mg COD/g dry inoculum/hr; decomposition by a soil microflora: >64 days; inhibition of degradation of glucose by *Pseudomonas fluorescens*: 20 mg/L; inhibition of degradation by *E.coli*: >1000 mg/L; slow biodegradation when released on soil; may leach into ground water; slightly persistent in water with a half-life of 2-20 days; aerobic half-life: 1-4 weeks; anaerobic half-life: 1-4 weeks; ground water half-life: 2-4 weeks; can be detected in water by EPA Method 604: methylene chloride extraction by gas chromatography with flame ionization or electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** little or no bioconcentration expected to occur; the concentration found in fish tissues is expected to be somewhat higher than the average concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** intermediate in organic synthesis; indicator; synthesis of dyestuffs; pesticides; a reagent for the preparation of o-nitrophenyl esters used in peptide synthesis; pharmaceuticals; reagent for glucose tests

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 0.9 mg/L, algae (*Microcystis aeruginosa*): 27 mg/L, green algae (*Scenedesmus quadricauda*): 4.3 mg/L, protozoa (*Entosiphon sulcatum*): 0.4 mg/L, protozoa (*Uronema parduczi Chatton-L-woff*): 2.9 mg/L; bacteria (*E. coli*): LD<sub>50</sub>: 1000 mg/L; algae (*Scenedesmus*): LD<sub>50</sub>: 36 mg/L; Arthropod (*Daphnia*): LD<sub>50</sub>: 60 mg/L; Fish (bluegill): 24-28 hr TLm: 67-46.3 mg/L

**EXPOSURE ROUTES:** fugitive emissions during production and use as a chemical intermediate; ambient air via inhalation

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life: 230 µg/L based on acute toxicity, 2700 µg/L/24 hr avg., concentration not to exceed 6200 µg/L any time; Criterion to protect saltwater aquatic life: 4580 µg/L based on acute toxicity; Criterion to protect human health: 70 µg/L; USSR MAC: 0.06 mg/L; the following are guidelines in drinking water set by some states: 290 µg/L (Kansas), 83 µg/L (Maine)

**PROBABLE FATE:** *photolysis*: slow photolysis very likely to occur, if released to water, will be lost to photolysis; *oxidation*: oxidation by hydroxy radical attack, half-life: 14 hr, photooxidation half-life in air: 7-71 hrs; *hydrolysis*: slight potential for hydrolysis after adsorption by clay materials; *volatilization*: not an important process, if released to water will volatilize, half-life: 12 days in a model river;  *sorption*: adsorbed to a moderate degree by clay materials, adsorption to sediment is minor; *biological processes*: no bioaccumulation; very resistant to biodegradation under natural conditions

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Gravity oil separation*, not available, 150; *Sedimentation*, >47, <10; *Activated sludge*, >99, <0.04; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 20; removed by gravitational settling and washout in rain

**KEY REFERENCES:** 21; 22; 23; 24; 25; 26; 27; 28; 30

#### 4-NITROPHENOL ( $\text{C}_6\text{H}_5\text{NO}_3$ , 139.11)

**CAS/DOT IDENTIFICATION #:** 100-02-7/UN 1663

**SYNONYMS:** 4-hydroxynitrobenzene, niphen, nitrophenol, p-nitrophenol, PNP

**PHYSICAL PROPERTIES:** colorless to slightly yellow crystals; odorless; sweetish, then burning taste; moderately soluble in cold water; soluble in hot water, alcohol, ether, chloroform, hydroxides, and carbonates; MP (113-114°C); BP (279°C, decomposes); DN (1.479-1.495  $\text{g/cm}^3$  @ 20°C); SG (1.48); VP (7 mmHg @ 165°C); VD (1.244 @ 65°C); Log Kow (1.91); H ( $3.31 \times 10^{-8}$  atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** incompatible with oxidizing materials, strong bases, and organics; combustible solid; AT (283°C); FP (192°C)

**BIOLOGICAL PROPERTIES:** 95% removal @ 20°C in activated sludge at a rate of 18 mg COD/g dry inoculum/hr; 2% removal after 48 hr incubation with an initial concentration of 200 mg/L; decomposition by a soil microfla: 16 days; inhibition of degradation of glucose by *Pseudomonas fluorescenes*: 20 mg/L; inhibition of degradation by *E.coli*: >100 mg/L; aerobic half-life: 7 days; anaerobic half-life: 6.8-9.8 days; surface water half-life: 7 days; ground water half-life: 1.5-9.8 days; can be detected in water by EPA Method 604: methylene chloride extraction by gas chromatography with flame ionization or electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** little or no bioaccumulation should occur; BCF (fathead minnow, 28-day test): 76; BCF (golden orfe, 3-day test): 58; bioconcentration in green algae (*Chlorella fusca*): 11

**ORIGIN/INDUSTRY SOURCES/USES:** intermediate in organic synthesis; dyes; drugs; fungicide for leather; indicator in 0.1% alcohol solution; production of parathion

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 4 mg/L, algae (*Microcystis aeruginosa*): 56 mg/L, green algae (*Scenedesmus quadricauda*): 7.4 mg/L, protozoa (*Entosiphon sulcatum*): 0.83 mg/L, protozoa (*Uronema parduczi* *Chatton-L-woff*): 0.89 mg/L; bacteria (*E. coli*): LD<sub>0</sub>: 100 mg/L; algae (*Scenedesmus*): LD<sub>0</sub>: 42 mg/L; Arthropod (*Daphnia*): LD<sub>0</sub>: 14 mg/L; Fish (*Varion (F)*): 6 hr TLm: 4-6 mg/L in distilled water, 30-33 mg/L in hard water

**EXPOSURE ROUTES:** ingestion; inhalation; dermal contact; wastewater; fugitive emissions during its production and use as a chemical intermediate; vehicle exhaust emissions

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 230  $\mu\text{g/L}$  based on acute toxicity, 240  $\mu\text{g/L}/24\text{-hr}$  avg., concentration not to exceed 550  $\mu\text{g/L}$  any time; **Criterion to protect saltwater aquatic life:** 4580  $\mu\text{g/L}$  based on acute toxicity, 53  $\mu\text{g/L}/24\text{-hr}$  avg., concentration not to exceed 120  $\mu\text{g/L}$  any time; **Criterion to protect human health:** 70

µg/L; USSR MAC: 0.02 mg/L; the following are guidelines in drinking water set by some states: 290 µg/L (Kansas), 83 µg/L (Maine)

**PROBABLE FATE:** *photolysis*: slow process, but might be only degradation process that occurs, atmospheric and aqueous photolytic half-life: 13.7 days, in clear surface waters, half-life: 2-14 days and faster if the water is acidic or contains nitrate or nitrite ions; *oxidation*: attack by hydroxyl radicals at C-2 and C-4 positions occurs, half-life: 14 hrs, photooxidation half-life in water; 21 days–5.6 yrs, photooxidation half-life in air: 6 days; *hydrolysis*: slight possibility of hydrolysis to 1,4-benzoquinone after sorption by clay minerals; *volatilization*: not an important process; *sorption*: slight potential for irreversible sorption by clay minerals; *biological processes*: no bioaccumulation, resists biodegradation under natural conditions and inhibits microbial growth

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Sedimentation*, 0, negative removal; *Sedimentation with chemical addition (lime, polymer)*, >9, <10; *Aerated lagoons*, >23, <10; *Activated sludge*, >99, <0.9; *Powdered activated carbon adsorption* (based on synthetic wastewater), 97, 60; *continuous or semicontinuous activated sludge biological treatment simulators*: 90-100% removal

**KEY REFERENCES:** 19; 21; 22; 23; 24; 25; 26; 28

#### p-CHLORO-M-CRESOL (C<sub>7</sub>H<sub>7</sub>ClO, 142.58)

**CAS/DOT IDENTIFICATION #:** 59-50-7/UN not available

**SYNONYMS:** 4-chloro-3-methylphenol, 4-chloro-m-cresol, 2-chloro-5-hydroxytoluene, PCMC

**PHYSICAL PROPERTIES:** odorless crystals; phenolic odor; MP (66°C); BP (235°C); OT (0.1 mg/kg detection in water); solubility in water (3850 mg/L @ 20°C); Log Kow (2.95); Log Poct (3.10)

**CHEMICAL PROPERTIES:** information not available

**BIOLOGICAL PROPERTIES:** after 3 weeks of adaptation @ 20 mg/L @ 22°C: 30% degradation when product is sole carbon source/100% degradation with synthetic sewage-aerobic conditions; under anaerobic conditions, no degradation with or without synthetic sewage; if released to the atmosphere, it will degrade rapidly, with a half-life of 1.1 days; readily degradable under aerobic conditions, but not degradable under anaerobic conditions; Koc: 50; if released to soil, leaching is likely to occur; may be generally persistent in ground water where aerobic degradation is not able to occur; can be detected by EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** bioconcentration is not important

**ORIGIN/INDUSTRY SOURCES/USES:** formed through inadvertent formation in waters which have undergone chlorination treatment; external germicide; preservative for glues, gums, inks, textile and leather goods; medication; topical antiseptic; antifungal agent in eye drops; fungicide

**TOXICITY:** Fish: fathead minnows (*Pimephales promelas*): 96 hr TLm: 0.1-0.01 mg/L (static bioassay)

**EXPOSURE ROUTES:** evaporation or water releases from product formulation; consumption of contaminated drinking water; dermal and inhalation exposure through use of consumer products formulated with this compound

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** data not available; **Criterion to protect saltwater aquatic life:** data not available; **Criterion to protect human health:** data not available

**PROBABLE FATE:** *photolysis:* based on data for 4-chlorophenol, intramolecular photolysis may be a very important fate, reaction with photochemically produced hydroxyl radicals has a half-life of 1.1 days, will degrade through photolysis if released to water; *oxidation:* can occur, but probably cannot compete with biodegradation; *hydrolysis:* not important; *volatilization:* not important; *sorption:* data inconclusive, but potential for adsorption by organics exists; *biological processes:* no data on bioaccumulation, biodegradation data not applicable to environment; *other reactions/interactions:* can be chlorinated further by chlorine present in H<sub>2</sub>O

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 120; *Filtration*, 0, negative removal; *Sedimentation with chemical addition (lime, polymer)*, 44, 62; *Activated sludge*, 65->98, <4; *Activated sludge* (based on synthetic wastewater), ~100, <50; *Granular activated carbon adsorption*, >83, <0.1

**KEY REFERENCES:** 23; 25; 30

**PCB-1016 (a mixture of mono, di, and trichloroisomers of the polychlorinated biphenyls (PCB's), 257.9 avg.)**

**CAS/DOT IDENTIFICATION #:** 12674-11-2/UN 2315

**SYNONYMS:** Chlorodiphenyl, Aroclor 1016; PCPs, Polychlorinated Biphenyls, Aroclors®

**PHYSICAL PROPERTIES:** polychlorinated biphenyl containing 16% chlorine; the solubility of PCB decreases with increasing chlorination (0.04-0.2 ppm); colorless, mobile oil; soluble in oils and organic solvents; odorless; BP (325-356°C); DN (1.33 g/mL @ 25°C); SG (1.4); VP ( $4 \times 10^{-4}$  torr @ 25°C estimated); Log Kow (4.38)

**CHEMICAL PROPERTIES:** incompatible with strong oxidizers; generally nonflammable; chemically inert and stable to conditions of hydrolysis and oxidation in industrial use; FP (286°F)

**BIOLOGICAL PROPERTIES:** aerobic degradation in semicontinuous activated sludge process; 30% degradation of <1 mg/L concentration after 48 hrs incubation; partition coefficient between sediment and water:  $\sim 10^5$ ; 15-10% degradation of 1 mg in 48 hr, increased chlorine in molecule decreases degradation; catalytic dechlorination to biphenyl was achieved with 5% platinum or palladium on 60/80 mesh glass beads; 48% biodegraded @ the end of 28 days at 5 ppm concentration is a static flask screening procedure using BOD dilution water, settled domestic wastewater inoculum, at 10 ppm, 13% biodegraded; can be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** PCB's in pelagic organisms – a food chain interrelationship study: PCB concentration factor (wet weight): microplankton: 170000, macroplanktonic enphausiid (*Meganycitiphanes norvegica*): 50000; carnivorous decapod shrimp (*Sergestes arcticus*): 47000; (*Pasiphaea sivado*): 20000; myctophid fish, *Myctophus glaciale*: 6000; no biomagnification in this food chain, if whole organisms are considered; BCF (sheepshead minnow (*Cyprinodon variegatus*) whole body, 28 day): 25000 adult, 43100 juvenile, 14400 fry

**ORIGIN/INDUSTRY SOURCES/USES:** prepared by the chlorination of biphenyl; used in the electrical industry in capacitors and transformers; used in the formulation of lubricating and cutting oils; pesticides; adhesives; plastics; inks; paints; sealants

**TOXICITY:** *Pteronarcells*: LC50: 610 µg/L/96 hr, naid @ 10°C static bioassay; rainbow trout (*Salmo gairdneri*): LC50: 135 µg/L/96 hr, wt 5.6g @ 12°C static bioassay; Atlantic salmon (*Salmo salar*): LC50: 134 µg/L/96 hr, wt 5.6g @ 12°C static bioassay; brown trout (*Salmo trutta*): LC50: 138 µg/L/96 hr, wt 4.6g @ 12°C static bioassay; brook trout (*Salvelinus fontinalis*): LC50: >800 µg/L/96 hr, wt 3.0g @ 12°C static bioassay; more information listed in the references below

**EXPOSURE ROUTES:** inhalation of fume or vapor; percutaneous adsorption of liquid; ingestion; eye and skin contact; landfills containing PCB waste materials and products; incineration of municipal refuse and sewage sludge; waste transformer fluid disposal to open areas; food and drinking water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.014 µg/L/24-hr avg.; **Criterion to protect saltwater aquatic life:** 0.030 µg/L/24-hr avg.; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 0.00079 µg/L; maximum contaminant level in drinking water: 0.5 µg/L (for PCB's as decachlorobiphenyl)

**PROBABLE FATE:** *photolysis*: too slow to be important, vapor-phase reaction with hydroxyl radicals has a half-life of 27.8 days to 3.1 months; *oxidation*: not important; *hydrolysis*: not important; *volatilization*: slow volatilization is the cause of global distribution of PCB's, but is inhibited by adsorption, may be significant over time, rapid volatilization from water in the absence of adsorption, half-life of 2-7 yrs in typical water bodies; *sorption*: PCB's are rapidly adsorbed onto solids, especially organic matter, and are often immobilized in sediments, but may reenter solution; *biological processes*: strong bioaccumulation, mono-di, -and tri- chlorinated biphenyls are gradually biodegraded, biodegradation is probably the ultimate degradation process in water and soil

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 1.3; *Gas flotation*, 0, negative removal; *Activated sludge* (based on synthetic wastewater), 47, 2,650; *wet and dry deposition*

**KEY REFERENCES:** 11; 21; 23; 25; 28; 30

**PCB-1221 (a mixture of polychlorinated biphenyls (PCB's) which is about 21% chlorine by weight, 200.7 avg.)**

**CAS/DOT IDENTIFICATION #:** 11104-28-2/UN 2315

**SYNONYMS:** Chlorodiphenyl (21 percent Cl), Aroclor 1221; PCPs, Polychlorinated Biphenyls, Aroclors®

**PHYSICAL PROPERTIES:** polychlorinated biphenyl containing 21% chlorine; the solubility of PCB decreases with increasing chlorination (0.04-0.2 ppm); colorless, viscous oily liquid; BP (275-320°C); DN (1.182-1.192 g/mL @ 25°C); SG (1.15); VP ( $6.7 \times 10^{-3}$  torr @ 25°C estimated); solubility in water (15 mg/L @ 25°C); Log Kow (2.8)

**CHEMICAL PROPERTIES:** stable; FP (286°C)

**BIOLOGICAL PROPERTIES:** aerobic degradation in semicontinuous activated sludge process; 80% degradation of <5 mg/L concentration after 48 hrs incubation; partition coefficient between sediment and water:  $\sim 10^3$ ; 15-10% degradation of 1 mg in 48 hr, increased chlorine in molecule decreases degradation; catalytic dechlorination to biphenyl was achieved with 5% platinum or palladium on 60/80 mesh glass beads; has a tendency to leach through soil; can be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** PCB's in pelagic organisms – a food chain interrelationship study: PCB concentration factor (wet weight): microplankton: 170,000, macroplanktonic enphausiid (*Meganyctiphanes norvegica*): 50,000; carnivorous decapod shrimp (*Sergestes arcticus*): 47,000; (*Pasiphaea sivado*): 20,000; myctophid fish, *Myctophus glaciale*: 6,000; no bio-magnification in this food chain, if whole organisms are considered; bioconcentrates significantly

**ORIGIN/INDUSTRY SOURCES/USES:** prepared by the chlorination of biphenyl; used in the electrical industry in capacitors and transformers; used in the formulation of lubricating and cutting oils; pesticides; adhesives; plastics; inks; paints; sealants; gas transmission turbine hydraulics; rubber plasticizers

**TOXICITY:** data not available

**EXPOSURE ROUTES:** inhalation of fume or vapor; percutaneous adsorption of liquid; ingestion; eye and skin contact; landfills containing PCB waste materials and products; incineration of municipal refuse and sewage sludge; waste transformer fluid disposal to open areas; food and drinking water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.014 µg/L/24-hr avg.; **Criterion to protect saltwater aquatic life:** 0.030 µg/L/24-hr avg.; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 0.00079 µg/L; maximum contaminant level in drinking water: 0.5 µg/L (for PCB's as decachlorobiphenyl)

**PROBABLE FATE:** **photolysis:** too slow to be important, vapor-phase reaction with hydroxyl radicals has a half-life of 12.9 to 27.8 days; **oxidation:** not important; **hydrolysis:** not important; **volatilization:** slow volatilization distributes PCB's globally, but is inhibited by adsorption, significant volatilization from soil surfaces; rapid volatilization from water in the absence of adsorption, half-life of 2 months-1 yr in typical water bodies; **sorption:** PCB's are rapidly adsorbed onto solids, especially organic matter, and are often immobilized in sediments, but may reenter solution, adsorption to sediment and suspended matter will be an important fate process if released to water; **biological processes:** strong bioaccumulation, mono-, di-, and trichlorinated biphenyls are gradually biodegraded, readily biodegradable; biodegradation is probably the ultimate degradation process in water and soil

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 0.1; *Activated sludge* (based on synthetic wastewater),  $\sim 100$ , <50; *Powdered activated carbon adsorption* (based on synthetic wastewater),  $\sim 100$ , 1; *wet and dry deposition* (dry deposition is more important)

**KEY REFERENCES:** 21; 23; 25; 28; 30

**PCB-1232 (a mixture of polychlorinated biphenyls (PCB's) which is about 32% chlorine by weight, 232.2 avg.)**

**CAS/DOT IDENTIFICATION #:** 11141-16-5/UN 2315

**SYNONYMS:** Chlorodiphenyl (32 percent Cl), Aroclor 1232; PCPs, Polychlorinated Biphenyls, Aroclors®

**PHYSICAL PROPERTIES:** polychlorinated biphenyl containing 32% chlorine; the solubility of PCB decreases with increasing chlorination (0.04-0.2 ppm); colorless, viscous oily liquid; BP (290-325°C); DN (1.270-1.280 g/mL @ 15.5°C); SG (1.24); VP ( $4.06 \times 10^{-3}$  torr @ 25°C estimated); solubility in water (1.45 mg/L @ 25°C); Log Kow (3.2)

**CHEMICAL PROPERTIES:** stable; FP (286°F)

**BIOLOGICAL PROPERTIES:** partition coefficient between sediment and water:  $\sim 10^5$ ; 15-10% degradation of 1 mg in 48 hr, increased chlorine in molecule decreases degradation; catalytic dechlorination to biphenyl was achieved with 5% platinum or palladium on 60/80 mesh glass beads; has a tendency to leach through soil; can be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** PCB's in pelagic organisms – a food chain interrelationship study: PCB concentration factor (wet weight): microplankton: 170,000, macroplanktonic euphausiid (*Meganyctiphanes norvegica*): 50,000; carnivorous decapod shrimp (*Sergestes arcticus*): 47,000; (*Pasiphaea sivado*): 20,000; myctophid fish, *Myctophus glaciale*: 6,000; no bio-magnification in this food chain, if whole organisms are considered; bioconcentrates significantly

**ORIGIN/INDUSTRY SOURCES/USES:** prepared by the chlorination of biphenyl; used in the electrical industry in capacitors and transformers; used in the formulation of lubricating and cutting oils; pesticides; adhesives; plastics; inks; paints; sealants; gas transmission turbine hydraulics; rubber plasticizers

**TOXICITY:** data not available

**EXPOSURE ROUTES:** inhalation of fume or vapor; percutaneous adsorption of liquid; ingestion; eye and skin contact; landfills containing PCB waste materials and products; incineration of municipal refuse and sewage sludge; waste transformer fluid disposal to open areas; food and drinking water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.014 µg/L/24-hr avg.; **Criterion to protect saltwater aquatic life:** 0.030 µg/L/24-hr avg.; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 0.00079 µg/L; maximum contaminant level in drinking water: 0.5 µg/L (for PCB's as decachlorobiphenyl)

**PROBABLE FATE:** **photolysis:** too slow to be important, vapor-phase reaction with hydroxyl radicals has a half-life of 12.9 days to 3.1 months; **oxidation:** not important; **hydrolysis:** not important; **volatilization:** slow volatilization distributes PCB's globally, but is inhibited by adsorption, significant volatilization from soil surfaces; rapid volatilization from water in the absence of adsorption, half-life of 2 months-1 yr in typical water bodies; **sorption:** PCB's are

rapidly adsorbed onto solids, especially organic matter, and are often immobilized in sediments, but may reenter solution, adsorption to sediment and suspended matter will be an important fate process if released to water; **biological processes:** strong bioaccumulation, mono-di, -and tri-chlorinated biphenyls are gradually biodegraded, readily biodegradable; biodegradation is probably the ultimate degradation process in water and soil

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Gravity oil separation*, not available, 0.63; *Filtration*, 16, 480; *Activated sludge* (based on synthetic wastewater),  $\sim 100$ ,  $<50$ ; *Powdered activated carbon adsorption* (based on synthetic wastewater),  $\sim 100$ , 0.1; *wet and dry deposition* (dry deposition is more important)

**KEY REFERENCES:** 21; 23; 25; 28; 30

**PCB-1242 (a mixture of polychlorinated biphenyls (PCB's) which is about 42% chlorine by weight, 266.5 avg.)**

**CAS/DOT IDENTIFICATION #:** 53469-21-9/UN 2315

**SYNONYMS:** Chlorodiphenyl (42 percent Cl), Aroclor 1242; PCPs, Polychlorinated Biphenyls, Aroclors®

**PHYSICAL PROPERTIES:** polychlorinated biphenyl containing 42% chlorine; the solubility of PCB decreases with increasing chlorination (0.04-0.2 ppm); colorless to dark brown liquid, viscous oily liquid; hydrocarbon odor; slightly soluble; BP (325-366°C); DN (1.381-1.392 g/mL @ 25°C); SG (1.35); VP ( $4.06 \times 10^{-4}$  torr @ 25°C estimated); solubility in water (0.24 mg/L @ 25°C); Log Kow (4.11); H ( $5.7 \times 10^{-4}$  atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** stable; nonflammable; FP (195°C)

**BIOLOGICAL PROPERTIES:** aerobic degradation in semicontinuous activated sludge process; 26% degradation of  $<1$  mg/L concentration after 48 hrs incubation; partition coefficient between sediment and water:  $\sim 10^5$ ; 15-10% degradation of 1 mg in 48 hr, increased chlorine in molecule decreases degradation; catalytic dechlorination to biphenyl was achieved with 5% platinum or palladium on 60/80 mesh glass beads; has a tendency to leach through soil; can be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** PCB's in pelagic organisms – a food chain interrelationship study: PCB concentration factor (wet weight): microplankton: 170,000, macroplanktonic enphausiid (*Meganyctiphanes norvegica*): 50,000; carnivorous decapod shrimp (*Sergestes arcticus*): 47,000; (*Pasiphaea sivado*): 20,000; myctophid fish, *Myctophus glaciale*: 6,000; no bio-magnification in this food chain, if whole organisms are considered; bioconcentrates significantly in aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES:** prepared by the chlorination of biphenyl; used in the electrical industry in capacitors and transformers; used in the formulation of lubricating and cutting oils; pesticides; adhesives; plastics; inks; paints; sealants; gas transmission turbine hydraulics; rubber palsticizers

**TOXICITY:** data not available

**EXPOSURE ROUTES:** inhalation of fume or vapor; percutaneous adsorption of liquid; ingestion; eye and skin contact; volatilization from ground surfaces; landfills containing PCB waste materials and products; incineration of municipal refuse and sewage sludge; waste transfer fluid disposal to open areas; food and drinking water; contaminated fish is primary

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.014 µg/L/24-hr avg.; **Criterion to protect saltwater aquatic life:** 0.030 µg/L/24-hr avg.; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 0.00079 µg/L; maximum contaminant level in drinking water: 0.5 µg/L (for PCB's as decachlorobiphenyl)

**PROBABLE FATE:** *photolysis:* inhibited by presence of oxygen, but possibly the only degradative pathway for highly chlorinated PCB's, vapor-phase reaction with hydroxyl radicals has a half-life of 27.8 days to 4.75 months; *oxidation:* not important; *hydrolysis:* not important; *volatilization:* slow volatilization distributes PCB's globally, but is inhibited by adsorption, significant volatilization from soil surfaces over time; rapid volatilization from water in the absence of adsorption, half-life of 2-7 yrs in typical water bodies; *sorption:* PCB's are rapidly adsorbed onto solids, especially organic matter, and are often immobilized in sediments, but may reenter solution, adsorption to sediment and suspended matter will be an important fate process if released to water; *biological processes:* strong bioaccumulation, mono-di, -and tri- chlorinated biphenyls are gradually biodegraded, readily biodegradable; biodegradation is probably the ultimate degradation process in water and soil

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 3.6; *Gas flotation*, 0, negative removal; *Filtration*, 16, 480; *Activated sludge* (based on synthetic wastewater), 66, 1700; *wet and dry deposition*

**KEY REFERENCES:** 21; 23; 25; 28; 30

**PCB-1248 (a mixture of polychlorinated biphenyls (PCB's) which is about 48% chlorine by weight, 299.5 avg.)**

**CAS/DOT IDENTIFICATION #:** 12672-29-6/UN 2315

**SYNONYMS:** Chlorodiphenyl (48 percent Cl), Aroclor 1248; PCPs, Polychlorinated Biphenyls, Aroclors®, Kanechlor-400

**PHYSICAL PROPERTIES:** polychlorinated biphenyl containing 48% chlorine; the solubility of PCB decreases with increasing chlorination (0.04-0.2 ppm); colorless liquid, viscous oily liquid; practically odorless; BP (340-375°C); DN (1.405-1.415 g/mL @ 15.5°C); SG (1.35); VP ( $4.94 \times 10^{-4}$  torr @ 25°C estimated); solubility in water (0.054 mg/L @ 25°C); Log Kow (5.75 (estimated)); H ( $3.5 \times 10^{-3}$  atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** chemically inert and stable to conditions of hydrolysis and oxidation in industrial use; stable; nonflammable; FP (286°F)

**BIOLOGICAL PROPERTIES:** aerobic degradation in semicontinuous activated sludge process; 26% degradation of <1 mg/L concentration after 48 hrs incubation; partition coefficient between sediment and water:  $\sim 10^5$ ; 15-10% degradation of 1 mg in 48 hr, increased chlorine in molecule decreases degradation; catalytic dechlorination to biphenyl was achieved with 5% platinum or palladium on 60/80 mesh glass beads; complete dechlorination @ 69% nickel on Kiselguhr in the presence of sodium hydroxide and 50 atm of hydrogen @ 115°C for 6 hr; can

be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** PCB's in pelagic organisms – a food chain interrelationship study: PCB concentration factor (wet weight): microplankton: 170,000, macroplanktonic euphausiid (*Meganyctiphanes norvegica*): 50,000; carnivorous decapod shrimp (*Sergestes arcticus*): 47,000; (*Pasiphaea sivado*): 20,000; myctophid fish, *Myctophus glaciale*: 6,000; no bioaccumulation in this food chain, if whole organisms are considered; bioconcentrates significantly in aquatic organisms; BCF (channel catfish *Ictalurus punctatus*): 56,400 whole body, 77 day

**ORIGIN/INDUSTRY SOURCES/USES:** prepared by the chlorination of biphenyl; used in the electrical industry in capacitors and transformers; used in the formulation of lubricating and cutting oils; pesticides; adhesives; plastics; inks; paints; sealants; gas transmission turbine hydraulics; rubber plasticizers

**TOXICITY:** rainbow trout (*Salmo gairdneri*): LC50: 54 µg/L/96 hr, wt 1.8g @ 17°C static bioassay; bobwhite quail: LC50: 10 days old, oral 1175 ppm, 5-day diest; Japanese quail: 14 days old, oral LC50: 4844 ppm; yellow perch (*Perca flavescens*): >100 µg/L/96 hr, wt. 1.1g @ 17°C static bioassay; Cladoceran (*Daphnia magna*): LC50: 2.6 µg/L/2 weeks; pink shrimp (*Panaeus duorarum*): 32 µg/L/48 hr; more information listed in the references below

**EXPOSURE ROUTES:** inhalation of fume or vapor; percutaneous adsorption of liquid; ingestion; eye and skin contact

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life: 0.014 µg/L/24-hr avg.; Criterion to protect saltwater aquatic life: 0.030 µg/L/24-hr avg.; Criterion to protect human health: preferably 0; lifetime cancer risk of 1 in 100,000: 0.00079 µg/L; maximum contaminant level in drinking water: 0.5 µg/L (for PCB's as decachlorobiphenyl)

**PROBABLE FATE:** *photolysis*: inhibited by presence of oxygen, but possibly the only degradative pathway for highly chlorinated PCB's; *oxidation*: not important; *hydrolysis*: not important; *volatilization*: slow volatilization distributes PCB's globally, but is inhibited by adsorption; *sorption*: PCB's are rapidly adsorbed onto solids, especially organic matter, and are often immobilized in sediments, but may reenter solution; *biological processes*: strong bioaccumulation

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Filtration*, 16, 480; *Activated sludge* (based on synthetic wastewater), 0, not available

**KEY REFERENCES:** 11; 21; 23; 25; 28; 30

**PCB-1254 (a mixture of polychlorinated biphenyls (PCB's) which is about 54% chlorine by weight, 328.4 avg.)**

**CAS/DOT IDENTIFICATION #:** 11097-69-1/UN 2315

**SYNONYMS:** Chlorodiphenyl (54 percent Cl), Aroclor 1254; PCPs, Polychlorinated Biphenyls, Aroclors®

**PHYSICAL PROPERTIES:** polychlorinated biphenyl containing 54% chlorine; the solubility of PCB decreases with increasing chlorination (0.04-0.2 ppm); pale, yellow, viscous liquid; mild, hydrocarbon odor; MP (10°C); BP (365-390°C); DN (1.47-1.49 g/mL @ 90°C); SG (1.505); VP ( $7.71 \times 10^{-5}$  torr @ 25°C estimated); VD (11.2); VS (1800-2500 cP @ 37.8°C); solubility in water (0.0122 mg/L @ 25°C); Log Kow (6.03); H ( $8.37 \times 10^{-3}$  atm·m<sup>3</sup>/mole); refractive index (1.629-1.641 @ 20°C)

**CHEMICAL PROPERTIES:** combustible; incompatible with strong oxidizers; attacks some forms of plastics, rubber, and coatings; FP (222°C)

**BIOLOGICAL PROPERTIES:** aerobic degradation in semicontinuous activated sludge process; partition coefficient between sediment and water:  $\sim 10^5$ ; 15% degradation of <1 mg after 48 hr incubation, increased chlorine in molecule decreases degradation; generally resistant to biodegradation; catalytic dechlorination to biphenyl was achieved with 5% platinum or palladium on 60/80 mesh glass beads; has a tendency to leach through soil; can be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** PCB's in pelagic organisms – a food chain interrelationship study: PCB concentration factor (wet weight): microplankton: 170,000, macroplanktonic enphausiid (*Meganyctiphanes norvegica*): 50,000; carnivorous decapod shrimp (*Sergestes arcticus*): 47,000; (*Pasiphaea sivado*): 20,000; myctophid fish, *Myctophus glaciale*: 6,000; no bio-magnification in this food chain, if whole organisms are considered; bioconcentrates significantly

**ORIGIN/INDUSTRY SOURCES/USES:** prepared by the chlorination of biphenyl; used in the electrical industry in capacitors and transformers; used in the formulation of lubricating and cutting oils; pesticides; adhesives; plastics; inks; paints; sealants; gas transmission turbine hydraulics; rubber plasticizers

**TOXICITY:** data not available

**EXPOSURE ROUTES:** inhalation of fume or vapor; percutaneous adsorption of liquid; ingestion; eye and skin contact; landfills containing PCB waste materials and products; incineration of municipal refuse and sewage sludge; waste transformer fluid disposal to open areas; food and drinking water; contaminated fish; swimmers in polluted water

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.014 µg/L/24-hr avg.; **Criterion to protect saltwater aquatic life:** 0.030 µg/L/24-hr avg.; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 0.00079 µg/L; maximum contaminant level in drinking water: 0.5 µg/L (for PCB's as decachlorobiphenyl)

**PROBABLE FATE:** *photolysis:* suppressed by presence of oxygen, but possibly the only degradative mechanism for highly -chlorinated PCB's, vapor-phase reaction with hydroxyl radicals has a half-life of 3.1 months to 1.3 yrs; *oxidation:* not important; *hydrolysis:* not important; *volatilization:* slow volatilization distributes PCB's globally, but is inhibited by adsorption, significant volatilization from soil surfaces; rapid volatilization from water in the absence of adsorption, half-life of >4 yrs in typical water bodies; *sorption:* PCB's are rapidly adsorbed onto solids, especially organic matter, and are often immobilized in sediments, but may reenter solution, adsorption to sediment and suspended matter will be an important fate process if released to water; *biological processes:* strong bioaccumulation; biodegradation is probably the ultimate degradation process in water and soil

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Filtration*, 20, 650; *Activated sludge* (based on synthetic wastewater), 42, 2900; *wet and dry deposition* removal from the atmosphere

**KEY REFERENCES:** 21; 23; 25; 28; 30

**PCB-1260 (a mixture of polychlorinated biphenyls (PCB's) which is about 60% chlorine by weight, 372 avg.)**

**CAS/DOT IDENTIFICATION #:** 11096-82-5/UN 2315

**SYNONYMS:** Chlorodiphenyl (60 percent Cl), Aroclor 1260; PCPs, Polychlorinated Biphenyls, Aroclors®

**PHYSICAL PROPERTIES:** polychlorinated biphenyl containing 60% chlorine; the solubility of PCB decreases with increasing chlorination (0.04-0.2 ppm); light yellow, viscous oily liquid; MP ( $10^{\circ}\text{C}$ ); BP ( $385\text{-}420^{\circ}\text{C}$ ); DN ( $1.270\text{-}1.280\text{ g/mL @ }15.5^{\circ}\text{C}$ ); SG (1.58); VP ( $4.05 \times 10^{-5}$  torr @  $25^{\circ}\text{C}$  estimated); solubility in water ( $0.0027\text{ mg/L @ }25^{\circ}\text{C}$ ); Log Kow (7.14); H ( $7.1 \times 10^{-3}$  atm- $\text{m}^3/\text{mole}$ )

**CHEMICAL PROPERTIES:** stable; FP ( $286^{\circ}\text{F}$ )

**BIOLOGICAL PROPERTIES:** partition coefficient between sediment and water:  $\sim 10^5$ ; 15% degradation of  $<1$  mg after 48 hr incubation, increased chlorine in molecule decreases degradation; catalytic dechlorination to biphenyl was achieved with 5% platinum or palladium on 60/80 mesh glass beads; has a tendency to leach through soil; can be detected in water by EPA Method 608: gas chromatography, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** PCB's in pelagic organisms – a food chain interrelationship study: PCB concentration factor (wet weight): microplankton: 170,000, macroplanktonic enphausiid (*Meganyctiphanes norvegica*): 50,000; carnivorous decapod shrimp (*Sergestes arcticus*): 47,000; (*Pasiphaea sivado*): 20,000; myctophid fish, *Myctophus glaciale*: 6,000; no biomagnification in this food chain, if whole organisms are considered; bioconcentrates significantly

**ORIGIN/INDUSTRY SOURCES/USES:** prepared by the chlorination of biphenyl; used in the electrical industry in capacitors and transformers; used in the formulation of lubricating and cutting oils; pesticides; adhesives; plastics; inks; paints; sealants; gas transmission turbine hydraulics; rubber palsticizers

**TOXICITY:** data not available

**EXPOSURE ROUTES:** inhalation of fume or vapor; percutaneous adsorption of liquid; ingestion; eye and skin contact; landfills containing PCB waste materials and products; incineration of municipal refuse and sewage sludge; waste transformer fluid disposal to open areas; food and drinking water

**REGULATORY STATUS:** Criterion to protect freshwater aquatic life:  $0.014\ \mu\text{g/L}/24\text{-hr avg.}$ ; Criterion to protect saltwater aquatic life:  $0.030\ \mu\text{g/L}/24\text{-hr avg.}$ ; Criterion to protect human health: preferably 0; lifetime cancer risk of 1 in 100,000:  $0.00079\ \mu\text{g/L}$ ; maximum contaminant level in drinking water:  $0.5\ \mu\text{g/L}$  (for PCB's as decachlorobiphenyl)

**PROBABLE FATE:** *photolysis*: inhibited by presence of oxygen, but possibly the only degradative mechanism for highly -chlorinated PCB's, vapor-phase reaction with hydroxyl radicals has a half-life of 4.75 months-1.31 yrs; *oxidation*: not important; *hydrolysis*: not important; *volatilization*: slow volatilization distributes PCB's globally, but is inhibited by adsorption, significant volatilization from soil surfaces; rapid volatilization from water in the absence of adsorption, half-life of >60 yrs in typical water bodies; *sorption*: PCB's are rapidly adsorbed onto solids, especially organic matter, and are often immobilized in sediments, but may reenter solution, adsorption to sediment and suspended matter will be an important fate process if released to water; *biological processes*: strong bioaccumulation, mono-di, -and tri- chlorinated biphenyls are gradually biodegraded, readily biodegradable; biodegradation is probably the ultimate degradation process in water and soil

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Filtration*, 16, 480; *Activated sludge* (based on synthetic wastewater), 21, 3950; *wet and dry deposition*

**KEY REFERENCES:** 21; 23; 25; 28; 30

## PENTACHLOROPHENOL ( $\text{C}_6\text{HCl}_5\text{O}$ , 266.32)

**CAS/DOT IDENTIFICATION #:** 87-86-5/UN 2020

**SYNONYMS:** PCP, penta, santophen 20, chlorophen

**PHYSICAL PROPERTIES:** off-white powder; soluble in benzene; pungent, phenolic odor when hot; almost insoluble in water; soluble in ethyl ether and ethyl alcohol; MP (188-191°C); BP (310°C); DN (1.978 g/mL @ 22°C); SG (1.982); VP (0.00011 mmHg @ 25°C); VD (9.2); solubility in water (14 mg/L @ 20°C); HV (70.05 kJ/mole @ 25°C); Log Kow (5.01)

**CHEMICAL PROPERTIES:** reacts with strong oxidizing agents, strong bases, acid chlorides, and acid anhydrides

**BIOLOGICAL PROPERTIES:** decomposition rate in soil suspension, >72 days for complete disappearance; persistence in soil is relatively high; soil and aerobic half-lives: 23-178 days; surface water half-life: 1 hr-4.6 days; % degraded under anaerobic continuous flow conditions: 0-85%; ground water half-life: 46 days-4.2 yrs; anaerobic half-life: 42 days-4.2 yrs; can be detected in water by EPA Method 608: methylene chloride extraction followed by gas chromatography with electron capture or halogen specific detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (goldfish @ 0.2 ppm): 475; adsorbed by goldfish from water and quickly excreted as a sulfate conjugate, biological half-life: 10 hr; the concentration found in fish tissues is expected to be much higher than the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** insecticides; fungicides; pesticides; algicides; herbicides; preservation of wood and wood products; manufacture of sodium pentachloronaphthalene

**TOXICITY:** algae (*Chlorella pyrenoidosa*): toxic: 0.001 mg/L; guppy (*Poecilia reticulata*): 24 hr LC50: 0.38 ppm @ pH 7.3; goldfish: 24 hr LC50: 0.27 ppm, amount found in dead fish @ 0.2 ppm: 95  $\mu\text{g/g}$ ; more data available from referenced sources

**EXPOSURE ROUTES:** contaminated air in pressure treated log homes; low levels in drinking water and food; contaminated air at wood treatment facilities and lumber mills; dermal contact with pressure treated lumber; inhalation; skin adsorption; ingestion; eye and skin contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 55 µg/L based on acute toxicity, 3.2 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** 53 µg/L based on acute toxicity, 34 µg/L based on chronic toxicity; **Criterion to protect human health:** 30 µg/L based on organoleptic toxicity; lifetime health advisory: 200 µg/L set by EPA; WHO: 10 µg/L as a limit in drinking water; USSR MAC: 300 µg/L in water bodies used for domestic purposes; guideline set by EPA: 200 µg/L; the following are guidelines in drinking water set by some states: 6 µg/L (Maine), 30 µg/L (California), 200 µg/L (Arizona), 220 µg/L (Kansas and Minnesota)

**PROBABLE FATE:** *photolysis:* forms a variety of products, very important fate, aqueous photolytic half-life: 1 hr-4.6 days, reaction with chemically produced hydroxyl radicals will occur; *oxidation:* can occur, but relatively unimportant, photooxidation half-life in water: 2.75-145 days, photooxidation half-life in air: 5.8-58 days, photooxidation by U.V. light in aqueous medium @ 90-95°C: time for the formation of CO<sub>2</sub> (% theoretical): 25%: 31.7 hr, 75%: 180.7 hr; *hydrolysis:* not important; *volatilization:* not important; *sorption:* sorption by organic materials provides storage and transport process; *biological processes:* strongly bioaccumulated by many organisms, biodegraded gradually by microbes

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 330; *Gas flotation with chemical addition (calcium chloride, polymer)*, 0, negative removal; *Gas flotation with chemical addition (polymer)*, 9-19, 19; *Filtration*, 29->87, 7.5; *Sedimentation*, 55, 24; *Sedimentation with chemical addition (alum, polymer)*, >96, <0.4; *Aerated lagoons*, >71, <10; *Trickling Filters*, 0, negative removal; *Activated sludge*, 70->99, 240; *Granular activated carbon adsorption*, 63->97, 13; *Powdered activated carbon adsorption* (based on synthetic wastewater), 98, 240

**KEY REFERENCES:** 11; 19; 21; 23; 25; 26; 27; 30

## PHENANTHRENE (C<sub>14</sub>H<sub>10</sub>, 178.2)

**CAS/DOT IDENTIFICATION #:** 85-01-8/UN not available

**SYNONYMS:** phenanthrin

**PHYSICAL PROPERTIES:** colorless leaflets; faint, aromatic odor; MP (101°C); BP (340°C); SG (1.025); VP (6.8x10<sup>-4</sup> torr @ 20°C); VD (6.14); solubility in water (1.29 mg/L); Log Kow (4.46)

**CHEMICAL PROPERTIES:** may react with oxidizing materials; stable; FP (171°C)

**BIOLOGICAL PROPERTIES:** soil half-life: 16-200 days; surface water half-life: 3-25 hrs; ground water half-life: 32 days-1.10 yrs; aerobic half-life: 16-200 days; anaerobic half-life: 64 hrs-2.19 yrs

**BIOACCUMULATION:** analyses of soft tissues of 3 species of uniondale mussels from Lake George showed there was bioconcentration in these organisms, it was detected in some, but not all of the mussel samples

**ORIGIN/INDUSTRY SOURCES/USES:** dyestuffs; explosives; synthesis of drugs; biochemical research

**TOXICITY:** inhibition of photosynthesis of a freshwater, non-axenic unialgal culture of *Selenastrum capricornutum* @ 1% saturation: 96% carbon-14 fixation, @ 10% saturation, 104% carbon-14 fixation, @ 100% saturation, 76% carbon-14 fixation; Fish (*Neanthes arenaceodentata*): 96 hr TCLm in seawater @ 22°C: 0.6 ppm (initial concentration static bioassay)

**EXPOSURE ROUTES:** incomplete combustion of a variety of organic compounds including wood and fossil fuels; ingestion of contaminated food

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** insufficient data

**PROBABLE FATE:** **photolysis:** data inconclusive, photolysis is probably greatly hindered by strong adsorption, atmospheric and aqueous photolytic half-life: 3-25 hrs; **oxidation:** chlorine and/or ozone in sufficient quantities may oxidize phenanthrene, photooxidation half-life in air: 2.01-20.1 hrs; **hydrolysis:** not important; **volatilization:** probably not an important transport process; **sorption:** probably the dominant transport process, organic particulates preferred; **biological processes:** short-term bioaccumulation, metabolization and biodegradation are the principal fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ ): *Gravity oil separation*, not available, 3; *Gas flotation*, 45, ~600; *Gas flotation with chemical addition (calcium chloride, polymer)*, 83, 66; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, 40-70, 400; *Sedimentation*, 55-92, <14; *Sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Sedimentation with chemical addition (polymer)*, 0, negative removal; *Sedimentation with chemical addition (alum)*, 0, negative removal; *Aerated lagoons*, 0, negative removal; *Ozonation*, 48->97, 0.2; *Activated sludge*, 57->97, <2.5; *Granular activated carbon adsorption*, >63->97, 0.12; *Reverse osmosis*, 77, 0.7; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 2.2; *Continuous activated sludge biological treatment simulator*: 37% removal

**KEY REFERENCES:** 11; 23; 25; 26; 30

## PHENOL (C<sub>6</sub>H<sub>6</sub>O, 94.12)

**CAS/DOT IDENTIFICATION #:** 108-95-2/UN 1671, 2312, 2821

**SYNONYMS:** carboxylic acid, hydrobenzene, oxybenzene, phenic acid, phenylic acid, phenyl hydroxide, phenyl hydrate

**PHYSICAL PROPERTIES:** colorless or white solid when pure; soluble in water and ethyl alcohol; miscible with acetone; MP (40.85°C); BP (182°C); SG (1.065); ST (40.9 dynes/cm @ 20°C); VP (1 mm @ 40.1°C); VD (3.24); solubility in water (67,000 mg/L); Log Kow (1.46); H (1.3x10<sup>-6</sup> atm·m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** reacts with aluminum chloride in the presence of nitrobenzene; incompatible with strong oxidizers and calcium hypochlorite; HC (3053.3 kJ/mole); LEL/UEL (1.8%, 8.6%)

**BIOLOGICAL PROPERTIES:** 98% removal (measured as COD removal) obtained @ 20°C in activated sludge at a rate of 80 mg COD/g dry inoculum/hr; soil half-life: 1-10 days; surface water half-life: 0.22-2.4 days; ground water half-life: 0.5-7 days; aerobic half-life: ~.25-3.5 days; anaerobic half-life: 8-28 days

**BIOACCUMULATION:** can be detected in water by EPA Method 604: methylene chloride extraction followed by gas chromatography with flame ionization or electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of plywood, appliance resins, construction resins, and automotive resins; ear and nose drops; general disinfectant; throat lozengers; pharmaceutical acid; mouthwashes; reagent in chemical analysis

**TOXICITY:** not available

**EXPOSURE ROUTES:** primarily through inhalation of contaminated air; dermal exposure; through use of phenol containing medicines; eating certain foods, such as fried chicken, mountain cheese, and fish; smoking tobacco

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** 10,200 µg/L base on acute toxicity, 2,560 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** 5800 µg/L based on acute toxicity; **Criterion to protect human health:** 3,500 µg/L, 300 µg/L based on organoleptic properties; Czechoslovakia MAC in surface water: 0.2 mg/L, in drinking water: 0.005 mg/L; Mexico set a maximum permissible concentration of 1.0 µg/L in receiving waters used for drinking and recreational use, 0.1 µg/L in estuaries, and 0.01 µg/L in coastal waters; USSR MAC: 0.001 mg/L in drinking water; California and Kansas have set guidelines in drinking water of 1.0 µg/L and 300 µg/L respectively

**PROBABLE FATE: photolysis:** photooxidation of volatilized phenol and photolysis of phenolic anion may both take place at moderate rates, atmospheric and aqueous photolytic half-life: 1.9-7.2 days; **oxidation:** metal-catalyzed oxidation may take place in highly aerated waters, photooxidation half-life in water: 3.2-160 days, photooxidation half-life in air: 2.28-22.8 hrs; **hydrolysis:** not important; **volatilization:** very little, if any, volatilization of phenol occurs; **sorption:** not important; **biological processes:** no bioaccumulation, but very extensive biodegradation in natural waters; **other reactions/interactions:** chlorination of water may produce chlorophenols

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 2200; *Gas flotation*, 26-51, 1200; *Gas flotation with chemical addition (calcium chloride, polymer)*, 46-80, 87; *Gas flotation with chemical addition (polymer)*, 36-72, 18; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, 26->93, 3400; *Sedimentation*, 40->99, <21; *Sedimentation with chemical addition (alum, lime)*, 48-96, 25; *Sedimentation with chemical addition (lime, polymer)*, 18->37, <10; *Sedimentation with chemical addition (polymer)*, 14-29, 37; *Sedimentation with chemical addition (alum, polymer)*, 0, negative removal; *Sedimentation with chemical addition (alum)*, >80->90, <5; *Aerated lagoons*, >55->99, <14; *Trickling filters*, 0, negative removal; *Solvent extraction*, 65->99, 2200000; *Activated sludge*, 82->99, 79; *Granular activated carbon adsorption*, >60->96, 0.7; *Reverse osmosis*, 33-80, 2.9; *Powdered activated carbon adsorption*, >83->85, 95000; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, <50; *Continuous activated sludge biological treatment simulator*: 90.0%-99.9% removal

**KEY REFERENCES:** 19; 21; 23; 26

**PYRENE (C<sub>16</sub>H<sub>10</sub>, 202.26)**

**CAS/DOT IDENTIFICATION #:** 129-00-0/UN not available

**SYNONYMS:** benzo (d,e,f) phenanthrene

**PHYSICAL PROPERTIES:** MP (150°C); BP (393°C); DN (1.271 g/mL); VP (6.85x10<sup>7</sup> torr @ 20°C); solubility in water (0.14 mg/L); Log Kow (5.32)

**CHEMICAL PROPERTIES:** probably combustible; reacts with nitrogen oxides to form nitro derivatives; reacts with 70% nitric acid

**BIOLOGICAL PROPERTIES:** degradation in seawater by oil-oxidizing microorganisms (in presence of 0.19 mg/L 3,4-benzopyrene and 0.35 mg/L fluorene): initial concentration: 0.365 mg/L, after 12 days: 0.055 mg/L, 85% decrease; soil and aerobic half-lives: 210 days-5.2 yrs; surface water half-life: 0.68-2.04 hrs; ground water half-life: 1.15-10.4 yrs; anaerobic half-life: 2.3-20.8 yrs

**BIOACCUMULATION:** data not available

**ORIGIN/INDUSTRY SOURCES/USES:** biochemical research; starting material for the synthesis of benzo (a) pyrene

**TOXICITY:** Fish: mosquito fish: static bioassay: 96 hr TLM: 0.0026 mg/L @ 24-27°C

**EXPOSURE ROUTES:** inhalation; ingestion; skin contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** data not available; **Criterion to protect saltwater aquatic life:** data not available; **Criterion to protect human health:** 0 is recommended for maximum protection; Kansas has set a guideline of 0.029 µg/L in drinking water

**PROBABLE FATE:** **photolysis:** low solubility probably hinders photolysis, relatively unimportant fate, atmospheric and aqueous photolytic half-life: 0.68-2.04 hrs; **oxidation:** chlorine and/or ozone in sufficient quantities can oxidize dissolved pyrene, photooxidation half-life in air: 0.802-8.02 hrs; **hydrolysis:** not important; **volatilization:** probably not as important as adsorption as a transport process; **sorption:** adsorption onto suspended particles, biota, and sediment is probably the dominant transport process; **biological processes:** short-term bioaccumulation, metabolization and microbial degradation are the principal fates

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 37; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Filtration*, 0, negative removal; *Sedimentation*, 54-79, <18; *Sedimentation with chemical addition (lime, polymer)*, 70->87, <10; *Sedimentation with chemical addition (lime)*, 0, negative removal; *Aerated lagoons*, 67, 1; *Activated sludge*, 16-78, 2; *Activated sludge (based on synthetic wastewater)*, ~100, <50; *Granular activated carbon adsorption*, >83->97, 0.01; *Reverse osmosis*, 0, negative removal; *Continuous activated sludge biological treatment simulator:* 0% removal

**KEY REFERENCES:** 21; 23; 25; 26; 28; 30

**SELENIUM (Se, 78.96)**

CAS/DOT IDENTIFICATION #: 7782-49-2/UN 2658

SYNONYMS: Selenium dust

PHYSICAL PROPERTIES: MP (217°C); BP (685°C); VP (negligible)

**CHEMICAL PROPERTIES:** reacts with metal amides to form explosive products; violently reacts with barium carbide, bromine pentafluoride, and other acids and oxidizing agents

**BIOLOGICAL PROPERTIES:** can be detected in water by digestion followed by atomic adsorption, or by 0.45  $\mu$  filtration prior to the above analysis for the dissolved form

**BIOACCUMULATION:** concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** photographic devices; enamels; glass; paints; rubber; pesticides; inks; dandruff shampoos; plastics; lubricants; fungicides; used as a catalyst in the preparation of pharmaceuticals; manufacture of selenium rectifiers

**TOXICITY:** high acute and chronic toxicity to aquatic life

**EXPOSURE ROUTES:** mainly by burning coal and fly ash; inhalation; adsorption into digestive tract from drinking water; locally grown food; weathering of rocks; volcanic eruptions; incineration of rubber tires, paper, and municipal waste; ingestion

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 35  $\mu\text{g/L}/24$  hr avg., not to exceed 260  $\mu\text{g/L}$  for recoverable inorganic selenite; **Criterion to protect saltwater aquatic life:** 54  $\mu\text{g/L}/24$  hr avg., not to exceed 410  $\mu\text{g/L}$ ; **Criterion to protect human health:** 10  $\mu\text{g/L}$ ; foreign standards are as follows: Czechoslovakia: 0.1 mg/L in surface water, 0.05 mg/L in drinking water reserve, and 0.01 mg/L in drinking water; Germany: 0.008 mg/L in drinking water; Mexico: 0.01 mg/L for receiving waters used for drinking purposes; USSR MAC: 0.001 mg/L for drinking water; WHO: 0.01 mg/L in drinking water; guidelines for drinking water set by Maine and Minnesota: 0.01 mg/L and 0.045 mg/L respectively; EPA guideline in drinking water: 0.05 mg/L

**PROBABLE FATE:** **photolysis:** not important; **oxidation:** in aerobic waters, soluble anions are formed, under reducing conditions, selenium or metal selenides (insoluble) go into sediment, possibly forming volatile  $\text{H}_2\text{Se}$ ; **hydrolysis:**  $\text{SeO}_4^{2-}$  and  $\text{HSeO}_3^-$  (all soluble) are formed; **volatilization:**  $\text{H}_2\text{Se}$  can be formed, volatilization can also follow biomethylation; **sorption:** adsorbed by hydrous metal oxides (strongly), clays and organic chemicals, but only a small percentage of total Se is sorbed; **biological processes:** bioaccumulation by many species, possible biological redox reactions, and some biomethylation

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 20; *Gas flotation*, 0, negative removal; *Gas flotation with chemical addition (calcium chloride, polymer)*, 0, negative removal; *Gas flotation with chemical addition (alum, polymer)*, 0, negative removal; *Filtration*, 2-10, 48; *Sedimentation*, 60->99, <20; *Sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Sedimentation with chemical addition ( $\text{Fe}^{2+}$ , lime)*, 18-24, 20; *Sedimentation with chemical addition (lime)*, 0, negative removal; *Tertiary polishing lagoons*, 44, 18; *Aerated lagoons*, >50, <200; *Activated sludge*, 0, negative removal; *Granular activated carbon adsorption*, 17-

>50, 19; *Reverse osmosis*, >76-85, 5.5; *Powdered activated carbon adsorption (with activated sludge)*, 6->13, <30

**KEY REFERENCES:** 19; 21; 23; 27

## SILVER (Ag, 107.9)

**CAS/DOT IDENTIFICATION #:** 7440-22-4/UN none

**SYNONYMS:** argentium, shell silver, silver metal

**PHYSICAL PROPERTIES:** MP (962°C); BP (2210°C); SG (10.5 @ 20°C); VP (negligible)

**CHEMICAL PROPERTIES:** incompatible with acetylene, ammonia, and hydrogen peroxide; dust is flammable; blackened by ozone, sulfur and hydrogen sulfide; readily reacts with dilute nitric acid and hot concentrated sulfuric acid; superficially attacked by hydrochloric acid; inert to most acids

**BIOLOGICAL PROPERTIES:** can be detected in water by digestion followed by atomic adsorption or colorimetric determination or by inductively coupled plasma optical emission spectrometry, or by 0.45 μ filtration for dissolved silver

**BIOACCUMULATION:** concentration found in fish tissues is expected to be much higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of silverware, jewelry, coins, ornaments, plates, commutators, scientific instruments, automobile bearings, grids in storage batteries; chrome-nickel steels; solders and brazing alloys; bactericide for sterilizing water, fruit juices, vinegar; dental amalgams

**TOXICITY:** high chronic toxicity to aquatic life

**EXPOSURE ROUTES:** inhalation of fumes or dust; ingestion of solutions or dust; eye and skin contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** not to exceed  $\exp[1.72\ln(\text{hardness})-6.52]$  μg/L any time; **Criterion to protect saltwater aquatic life:** 2.3 μg/L; **Criterion to protect human health:** 50 μg/L; Maine recommends a concentration of 50 μg/L in drinking water

**PROBABLE FATE:** *photolysis:* not important in aquatic environment; *oxidation:* Ag and Ag<sup>+</sup> compounds (most insoluble) only forms usually present (both precipitate); *hydrolysis:* important only at high pH, where Ag<sub>2</sub>O may precipitate; *volatilization:* not important; *sorption:* strongly sorbed by MnO<sub>2</sub>, then released in saline water, some adsorption by clays and organic materials; *biological processes:* bioaccumulated by many aquatic organisms

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (μg/L)): *Gravity oil separation*, not available, 120; *Gas flotation with chemical addition (calcium chloride, polymer)*, 24->48, <13; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Gas flotation with chemical addition (alum, polymer)*, 44, 66l; *Filtration*, 11->50, 22; *Sedimentation*, 78->99, <45; *Sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Sedimentation with chemical addition (Fe<sup>2+</sup>, lime)*, >79->97, 12; *Sedimen-*

tation with chemical addition (sulfide), >90->99, <25; Sedimentation with chemical addition ( $BaCl_2$ ), 0, negative removal; Sedimentation with chemical addition (alum, polymer), 21, 11; Sedimentation with chemical addition (alum), 5-10, 120; Sedimentation with chemical addition (lime), 24->80, <4; Ozonation, 0, negative removal; Ion exchange, >99, <10; Activated sludge, 31->96, 32; Granular activated carbon adsorption, 7-36, 21; Reverse osmosis, 31-92, 25

**KEY REFERENCES:** 21; 23; 27; 28

### 2,3,7,8-TETRACHLORODIBENZO-p-DIOXIN ( $C_{12}H_4Cl_4O_2$ , 321.98)

**CAS/DOT IDENTIFICATION #:** 1746-01-6/ UN not available

**SYNONYMS:** dioxin, TCDBD, TCDD, 2,3,7,8-TCDD; tetradioxin, 2,3,6,7-tetrachlorodibenzo-p-dioxin

**PHYSICAL PROPERTIES:** white, crystalline solid; lipophilic; highly soluble in fats, oils, and non-polar solvents, slightly soluble in water (0.2-0.6  $\mu\text{g/L}$ ); MP (302-305  $^{\circ}\text{C}$ ); BP (412.2 $^{\circ}\text{C}$ ); DN (1.827  $\text{g/mL}$ ); VP ( $1.52 \times 10^{-9}$  mmHg @ 25 $^{\circ}\text{C}$ ); Log Kow (6.8); H ( $1.62 \times 10^{-5}$  atm- $\text{m}^3/\text{mole}$ )

**CHEMICAL PROPERTIES:** not volatile; decomposes within 21 sec @ 800 $^{\circ}\text{C}$ , highly stable; very toxic; caustic

**BIOLOGICAL PROPERTIES:** log Koc: 7.39 from 10 contaminated soils from NJ and MO; very resistant to all forms of degradation; most of this pollutant occurring in water is expected to be associated with sediments or suspended material; if released to soil, not expected to leach; after weathering in soil for 1-yr, 50-60% of the original conc. remained unchanged; half-life (soil): 1.15-1.62 yrs; half-life (surface water): 1.15-1.62 yrs; half-life (ground water): 2.29-3.23 yrs; aerobic half-life: 1.15-1.62 yrs; anaerobic half-life: 4.58-6.45 yrs; can be detected in water by EPA Method 613: methylene chloride extraction followed by transfer to benzene and capillary column gas chromatography/mass spectrometry with electron impact ionization, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** expected to bioconcentrate in aquatic organisms; BCF (fathead minnows): 29,200 (dry wt) and 5,840 (wet wt) over a 28 day exposure; elimination half-life: 14.5 days after exposure; Log BCF (rainbow trout): 3.2 during 4-5 exposures; Log BCF (fathead minnow): 3.9 during 4-5 exposures; Log BCF (snails, fish (*Gambusia*), daphnia): 4.3-4.4; Log BCF (duckweed, algae, catfish): 3.6-3.95

**ORIGIN/INDUSTRY SOURCES/USES:** not produced or commercially used in U.S.; formed in the production of 2,4,5-trichlorophenol and of a few chlorinated herbicides such as silvex; formed during combustion of chlorinated organic compounds; impurity in pesticides; has been tested for use in flameproofing polyesters; tested as an insecticide; used as a defoliant in Vietnam War

**TOXICITY:** one of the most toxic substances known, highly lethal at low doses to aquatic organisms, birds, and mammals

**EXPOSURE ROUTES:** released in stack emissions from incineration of municipal refuse and chemical wastes; exhaust from automobiles powered by leaded gasoline; emissions from wood burning in the presence of chlorine; in accidental fires involving transformers containing

PCBs and chlorinated benzenes; improper disposal of certain chlorinated chemical wastes; pulp and paper manufacturing plants; paper products; flue gases; fly ash; fish and cow's milk

**REGULATORY STATUS:** MCLG: 0 mg/L; MCL:  $3 \times 10^{-8}$  mg/L; HAL(child):  $1 \times 10^{-6}$  mg/L 1 day,  $1 \times 10^{-7}$  mg/L 10 days; **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; the concentration calculated to keep the lifetime cancer risk level below  $10^{-5}$  is  $4.55 \times 10^{-7}$  µg/L in 1979; to limit cancer risk to 1 in a million, a concentration of 0.0039 ng/L was established in 1980

**PROBABLE FATE:** *photolysis:* will not be an important process if reactive substrates are available, atmospheric photolytic half-life: 1.1-3.4 days, aqueous photolytic half-life: 1.1-3.4 days, photolysis half-life at the water's surface: 21 hr (summer), 118 hr (winter); *oxidation:* not an important process; *hydrolysis:* does not occur, if released to atmosphere, vapor phase TCDD may be degraded by reaction with hydroxyl radicals and direct photolysis; *volatilization:* not an important process, volatilization half-life: 46 days without considering adsorption, considering adsorption effects: >50 yrs; *sorption:* an important process; *biological processes:* bioaccumulation is possibly an important process

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): Currently, there is no data available on the TREATABILITY/REMOVABILITY for this pollutant; particulate-phase TCDD may be physically removed from air by wet and dry deposition

**KEY REFERENCES:** 19; 21; 23; 24; 25; 26; 29

### 1,1,2,2-TETRACHLOROETHANE (C<sub>2</sub>H<sub>2</sub>Cl<sub>4</sub>, 167.84)

**CAS/DOT IDENTIFICATION #:** 79-34-5/UN 1702

**SYNONYMS:** acetylene tetrachloride, bonoform, cellon, 1,1-dichloro-2,2-dichloroethane, westron

**PHYSICAL PROPERTIES:** dense, heavy, colorless, corrosive liquid; sweet, chloroform-like odor; very sparingly soluble in water; miscible with methanol, ethanol, benzene, ether, carbon tetrachloride, chloroform, carbon disulfide, dimethylformamide, oils; not an inert solvent; highest solvent power of the chlorinated hydrocarbons; solubility (2,900 ppm); MP (-43.8°C, -46.84°F); BP (146.4°C); DN (1.593 g/cm<sup>3</sup> @25°C); SG (1.586); VD (5.8); OT (1.5 ppm); VP (8 mm @20°C, 5.95 mm @ 25°C); Log Kow (2.39); H ( $3.8 \times 10^{-4}$ )

**CHEMICAL PROPERTIES:** nonflammable; corrosive; stable; reacts violently with N<sub>2</sub>O<sub>4</sub>, 2,4-dinitrophenyl disulfide, and on contact with Na or K; heating with solid KOH, spontaneously flammable chloro- or dichloroacetylene gas is produced, interaction with H<sub>2</sub>O causes hydrolysis; above 110°C hydrolysis and oxidation becomes rapid; heating to decomposition yields toxic hydrogen chloride gas fumes; incompatible with strong oxidizing agents, strong bases, strong reducing agents

**BIOLOGICAL PROPERTIES:** slowly biodegrades; some biodegradation when evaporation is very slow and the body of water is rich in microorganisms (i.e. eutropic lake); 1,1,1-trichloroethane is a product of biodegradation under anaerobic conditions; the log of the BCF in fish is 0.9-1; slightly enduring in water, half-life: 2-20 days; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 7 days-4 weeks; T.O.C. in water: 0.5 ppm

**BIOACCUMULATION:** not expected to bioconcentrate in aquatic organisms; concentration found in fish tissues is same as concentration found in water from which they came

**ORIGIN/INDUSTRY SOURCES/USES:** organic chemical industry, solvent for chlorinated rubber and other organic materials; paint; varnish; rust remover; soil fumigant; cleansing and degreasing metals; photo films; resins and waxes; extractant for oils and fats; herbicide; alcohol denaturant

**TOXICITY:** moderate acute toxicity to aquatic life; **Toxicity (Fish):** guppy (*Poecilia reticulata*): 7 d LC<sub>50</sub>: 37ppm **Toxicity (Mammals):** cats and rabbits: inhalation: no typical organ change: 100-160 ppm, 8 hr/d, 4 weeks; dog: oral dose: toxic: 0.7 g/kg, lethal: 0.3 ml/kg; the concentration calculated to keep the lifetime cancer risk level below 10<sup>-5</sup> is 1.8 µg/L

**EXPOSURE ROUTES:** ambient air near industrial sources; the greatest percentage (86%) was found in drinking water; listed as a contaminant found in drinking water for a survey of US cities; metal finishing industry

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** 170 µg/L/24 hr avg., concentration not to exceed 380 µg/L at any time; **Criterion to protect saltwater aquatic life:** 70 µg/L/24 hr avg., concentration not to exceed 160 µg/L at any time

**PROBABLE FATE: photolysis:** not significant in aquatic environment, photodissociation in stratosphere probably a significant fate; **oxidation:** not important in aquatic environment, oxidation is rapid above 110°C, photooxidation in the troposphere probably important; **hydrolysis:** too slow to be consequential, rapid above 110°C, expected to hydrolyze under alkaline conditions; first-order hydrolysis half-life: 45 days; **volatilization:** probable primary transport process, release to water will primarily be lost by volatilization in days to weeks, volatilization half-life in a model river and pond is estimated to be 6.3 hr and 3.5 days respectively, volatilization from dry soil will be fairly rapid; **biological processes:** NA; **evaporation** from water @ 25°C of 1 ppm solution is 50% after 56 min. and 90% after less than 120 min., evaporation rate: 0.65; **oxidative decomposition** occurs by UV radiation

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Sedimentation with chemical addition*, 30, 35; *Steam stripping*, 40->99, 32,000; *Solvent extraction*, 91-99, 4,200; *Activated sludge*, >22->44, <9; *Filtration and Sedimentation* indicated negative removal.

**KEY REFERENCES:** 19,21,22,23,24,25,26,27,28

## TETRACHLOROETHENE (Cl<sub>2</sub>C=CCl<sub>2</sub>, 165.82)

**CAS/DOT IDENTIFICATION #:** 126-18-4/UN 1897

**SYNONYMS:** ankilostin, antisol 1, carbon bichloride, carbon dichloride, ethylene tetrachloride, tetrachloroethylene, teraleno, tetralex, tetravec, tetropil, perchloroethylene

**PHYSICAL PROPERTIES:** colorless liquid; sharp, sweet odor; insoluble in water; miscible with alcohol, ether, chloroform, and benzene; MP (-23.35°C); BP (121.20°C); DN (1.6311); VP (18.47 mmHg @ 25°C); VD (5.83); OT (4.68 ppm); solubility in water (150 mg/L @ 20°C); Log Kow (3.40); H (28.7x10<sup>-3</sup> atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** extremely stable; resists hydrolysis; nonflammable; incompatible with strong oxidizers and chemically active metals; stable; reacts violently with concentrated nitric acid to yield CO<sub>2</sub>;

**BIOLOGICAL PROPERTIES:** 86% degraded under anaerobic continuous flow conditions; soil, surface water, and aerobic half-lives: 6 months-1 yr; ground water half-life: 12 months-2 yrs; anaerobic half-life: 98 days-4.5 yrs; can be detected in water by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** does not appear to bioconcentrate in fish or other aquatic organisms; concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** dry cleaning; textile processing; chemical intermediate; degreasing agent; rubber coatings; solvent soaps; painting inks; adhesives; glues; sealants; polishes; lubricants; silicones; insulating fluid and cooling gas in electrical transformers

**TOXICITY:** moderate acute and chronic toxicity to aquatic organisms

**EXPOSURE ROUTES:** ambient air; drinking water; auto brake cleaners; suede protectors; water repellents; silicone lubricants; dry cleaning establishments; industries manufacturing or using the chemical; inhalation of vapor; ingestion; skin and eye contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 5,280 µg/L based on acute toxicity, 840 µg/L based on chronic toxicity; **Criterion to protect saltwater aquatic life:** 10,200 µg/L based on acute toxicity, 450 µg/L based on chronic toxicity; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 8.0 µg/L; lifetime health advisory: 10 µg/L; EPA set a drinking water max. of 5 µg/L; WHO and Japan: 10 µg/L as a standard in drinking water; the following are guidelines set by some states in drinking water: 0.67 µg/L (New Hampshire), 1.0 µg/L (Arizona and New Jersey), 3.0 µg/L (Florida), 4.0 µg/L (California), 7.0 µg/L (Kansas and Vermont), 20.0 µg/L (Connecticut, Massachusetts, Wisconsin, and New Mexico), 35 µg/L (Maine)

**PROBABLE FATE:** **photolysis:** not important except as photooxidation, C-Cl bond can photolyze slowly; **oxidation:** tropospheric photooxidation by hydroxyl radicals yields trichloroacetyl chloride and phosgene, predominant fate, photooxidation half-life in air: 16-160 days; **hydrolysis:** probably too slow to be important; **volatilization:** rapid volatilization is the primary transport process; **sorption:** too slow to compete with volatilization; **biological processes:** moderate potential for bioaccumulation, possible biodegradation by higher organisms

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, >40; *Gas flotation with chemical addition (calcium chloride, polymer)*, 23-94, 580; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Gas flotation with chemical addition (alum, polymer)*, >10, <0.9; *Filtration*, 30->99, 49; *Sedimentation*, 34-76, <23; *Sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Sedimentation with chemical addition (alum, lime)*, 95, 13; *Sedimentation with chemical addition (alum, polymer)*, 15->44, 270; *Sedimentation with chemical addition (alum)*, 0, negative removal; *Sedimentation with chemical addition (lime)*, 0, negative removal; *Aerated lagoons*, >60, <10; *Steam stripping*, 78->99, <7; *Activated sludge*, 75->99, <7; *Granular activated carbon adsorption*, 68, 32; *Powdered activated carbon adsorption* (based on synthetic wastewater), 99, 7

**KEY REFERENCES:** 19; 21; 23; 26; 27; 31

### **THALLIUM (Tl, 204.4)**

**CAS/DOT IDENTIFICATION #:** 7440-28-0/UN not available

**SYNONYMS:** thallium salt

**PHYSICAL PROPERTIES:** soft, heavy metal; insoluble in water and organic solvents; MP (304°C); BP (1460°C); VP (negligible)

**CHEMICAL PROPERTIES:** not available

**BIOLOGICAL PROPERTIES:** can be detected in water by digestion followed by atomic adsorption measurement, or by 0.45  $\mu$  filtration for dissolved silver

**BIOACCUMULATION:** concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** obtained as a by-product from the flue dust generated during the roasting of pyrite ores in the smelting and refining of lead and zinc; rodenticides; fungicides; insecticides; catalysts in certain organic reactions; manufacture of optical lenses, fire works, and imitation precious jewelry

**TOXICITY:** high acute and chronic toxicity in aquatic organisms

**EXPOSURE ROUTES:** inhalation of dust or fume; ingestion; percutaneous adsorption; eye and skin contact; breathing workplace air; smoking cigarettes; coal burning and smelting

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 1,400  $\mu\text{g/L}$  based on acute toxicity, 40  $\mu\text{g/L}$  based on chronic toxicity; **Criterion to protect saltwater aquatic life:** 2130  $\mu\text{g/L}$  based on acute toxicity; **Criterion to protect human health:** 13  $\mu\text{g/L}$ ; USSR MAC: 0.1  $\mu\text{g/L}$  in water bodies used for domestic purposes; Kansas has set a guideline in drinking water of 13  $\mu\text{g/L}$

**PROBABLE FATE:** *photolysis:* not important; *oxidation:* Tl (III) present only in very oxidizing water, in reducing conditions, metallic Tl or sulfide may precipitate; *hydrolysis:* hydrolysis of  $\text{Tl}^{3+}$  to insoluble  $\text{Tl}(\text{OH})_3$ , unimportant because of low  $\text{Tl}^{3+}$  content of natural water; *volatilization:* data not available; *sorption:*  $\text{Tl}^+$  adsorbed strongly by clay minerals and to a lesser extent by hydrous metal oxides; *biological processes:* rapidly bioaccumulated by aquatic organisms

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, 2; *Gas flotation with chemical addition (calcium chloride, polymer)*, 0, negative removal; *Gas flotation with chemical addition (polymer)*, 0, negative removal; *Filtration*, >55, <10; *Sedimentation*, >55->83, <5; *Sedimentation with chemical addition ( $\text{Fe}^{2+}$ , lime)*, >55->88, <4; *Sedimentation with chemical addition (lime)*, >52->88, 3.4; *Aerated lagoons*, >44->80, <16; *Activated sludge*, 38, 29; *Reverse osmosis*, 70-89, 3.5

**KEY REFERENCES:** 21; 23; 27; 31

**TOLUENE (C<sub>6</sub>H<sub>5</sub>CH<sub>3</sub>, 92.15)**

CAS/DOT IDENTIFICATION #: 108-88-3/UN 1294

**SYNONYMS:** antisal-1A, benzene, methyl-, methacide, toluol, methane, phenyl-, methyl-benzene, methyl benzol, phenylmethane, toluosol

**PHYSICAL PROPERTIES:** colorless liquid; soluble in petroleum ether, alcohol, ether, acetate; sweet, pungent odor; insoluble in water; MP (-95°C); BP (111°C); DN (0.866 g/mL); SG (0.87); VP (36.7 mmHg @ 30°C); VS (0.59 cP @ 20°C); ST (29 dynes/cm); OT (2.14 ppm); Log Kow (2.69); H (5.93x10<sup>-3</sup> atm-m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** flammable liquid; reacts with oxidizing materials; HC (-17430 Btu/lb); FP (40°F); AT (480°C); LFL/UFL (1.27%, 7.1%)

**BIOLOGICAL PROPERTIES:** non-persistent in water, half-life <2 days; incubation with natural flora in the groundwater-in presence of the other components of high-octane gasoline (100 µl/L): biodegradation: 100% after 192 hr @ 13°C (initial concentration: 2.22 µl/L); soil, surface water, and aerobic half-life: 4-22 days; ground water half-life: 7 days-4 weeks; 75% degraded in an 8 day period under anaerobic continuous flow; can be detected in water by EPA Method 602: inert gas purge followed by gas chromatography with photoionization detection, or EPA Method 624: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** manufacture of benzoic acid, dyes, caprolactum, perfumes, benzaldehyde, artificial leather, saccharin, explosives, detergent, medicines; paints; resins; lacquers; plastic toys; gums; model airplanes

**TOXICITY:** Bacteria (*E. coli*): LD<sub>0</sub>: 200 mg/L; Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 29 mg/L, algae (*Microcystis aeruginosa*): 105 mg/L, green algae (*Scenedesmus quadricauda*): >400 mg/L, protozoa (*Entosiphon sulcatum*): 456 mg/L; protozoa (*Uronema parduczi* Chatton-L-woff): >450 mg/L; more data available from referenced sources

**EXPOSURE ROUTES:** derived from coal tar; inhalation; ingestion; adsorption of liquid; skin and eye contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 17,500 µg/L based on acute toxicity; **Criterion to protect saltwater aquatic life:** 6,300 µg/L based on acute toxicity, 5,000 µg/L based on chronic toxicity; **Criterion to protect human health:** 14.3 mg/L; lifetime health advisory: 2.42 mg/L; drinking water standard: 2.0 mg/L; USSR MAC: 5 mg/L in water bodies used for household and fishery purposes; the following are guidelines set by some states in drinking water: 2000 µg/L (Arizona, Kansas, Minnesota, and Vermont), 100 µg/L (California and Maine), 7.0 µg/L (Kansas and Vermont), 340 µg/L (Massachusetts), 343 µg/L (Wisconsin), 750 µg/L (New Mexico), 1000 µg/L (Connecticut)

**PROBABLE FATE:** **photolysis:** amount of dissociation to benzyl alcohol and benzaldehyde unknown, atmospheric photooxidation to benzaldehyde follows volatilization, probably principal fate; **oxidation:** only important as photooxidation, photooxidation half-life in water: 13-54 days, photooxidation half-life in air: 10 hrs-4.3 days; **hydrolysis:** not important; **volatilization:** volatilization occurs with a half-life of about 5 hrs; **sorption:** presumably adsorbed by or-

ganic materials; **biological processes:** bioaccumulation not important, metabolization produces acids (acetic, pyruvic, and hippuric)

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, >65; *Gas flotation*, >92, not detected; *Gas flotation with chemical addition (calcium chloride, polymer)*, 19-65, 1000; *Gas flotation with chemical addition (polymer)*, 59, 130; *Gas flotation with chemical addition (alum, polymer)*, 10, 4.5; *Sedimentation with chemical addition (lime, polymer)*, 0, negative removal; *Sedimentation with chemical addition (polymer)*, 20-39, 950; *Sedimentation with chemical addition (alum, lime)*, 76-96, 43; *Sedimentation with chemical addition (alum, polymer)*, 18-73, 990; *Sedimentation with chemical addition (alum)*, 49-93, 1260; *Sedimentation with chemical addition (lime)*, 0, negative removal; *Aerated lagoons*, >72->95, <14; *Steam stripping*, 95-96, 1950; *Ozonation*, 15-31, 1; *Activated sludge*, 49->99, 57; *Granular activated carbon adsorption*, 38->99, 80; *Powdered activated carbon adsorption* (based on synthetic wastewater), 91, 1700; *Reverse osmosis*, 3.8-12, 17.5

**KEY REFERENCES:** 21; 19; 23; 25; 26

### TOXAPHENE (C<sub>10</sub>H<sub>10</sub>Cl<sub>8</sub>, 413.80)

**CAS/DOT IDENTIFICATION #:** 8001-35-2/UN 2761

**SYNONYMS:** alltox, anatox, campheclor, camphene, octachlor-, camphochlor, canfeclor, esotonex, geniphene, melipax, motox, PCC, phenacide, phenatox, PKHF, toxakil, toxyphen

**PHYSICAL PROPERTIES:** yellow-to-amber waxy solid; smells like turpentine; almost insoluble in water; very soluble in aromatic hydrocarbons; MP (65-90°C); BP (decomposes >120°C); DN (1.65 @ 20°C); VP (0.2-0.4 mmHg @ 20°C); OT (0.14 ppm); solubility in water (1.75); Log Kow (2000); H (4.89x10<sup>-3</sup> atm·m<sup>3</sup>/mole);

**CHEMICAL PROPERTIES:** dehydrochlorinates in the presence of alkali, in prolonged exposure to sunlight, and at temperature > 155°C; reacts with bases; FP (29°C); LEL/UEL (1.1%, 6.4%)

**BIOLOGICAL PROPERTIES:** can be detected in water by EPA Method 608: gas chromatography, or EPA method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (grass shrimp (*Palaemonetes pugio*)): 800-1,200; BCF (sheepshead minnow (*Cyprinodon variegatus*)): 3,100-20,600; BCF (catfish fry): 91,000 X; more data available from referenced sources

**ORIGIN/INDUSTRY SOURCES/USES:** used for pest control for cotton crops, peas, soybeans, corn, wheat; in livestock and poultry; field crops; banned as a pesticide in the USA in 1982 by EPA except in Puerto Rico and the Virgin Island and in emergency situations

**TOXICITY:** grass shrimp (*Palaemonetes pugio*): 96 hr LC<sub>50</sub>: 0.0044 mg/L; sheepshead minnow (*Cyprinodon variegatus*): 96 hr LC<sub>50</sub>: 0.0011 mg/L; pinfish (*Lagodon rhomboides*): 96 hr LC<sub>50</sub>: 0.00053 mg/L; catfish: 96 hr LC<sub>50</sub>: 13 µg/L; bullhead: 96 hr LC<sub>50</sub>: 5 µg/L; goldfish: 96 hr LC<sub>50</sub>: 14 µg/L; minnow: 96 hr LC<sub>50</sub>: 14 µg/L; carp: 96 hr LC<sub>50</sub>: 4 µg/L; sunfish: 96 hr LC<sub>50</sub>: 13 µg/L; bluegill: 96 hr LC<sub>50</sub>: 183 µg/L; bass: 96 hr LC<sub>50</sub>: 2 µg/L; rainbow: 96 hr LC<sub>50</sub>: 11 µg/L; more data available from referenced sources

**EXPOSURE ROUTES:** outdoor air; soil; food; fish and other seafood; contaminated water; farmers and pesticide applicators exposed; inhalation; skin adsorption; eye and skin contact

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 0.013 µg/L/24 hr avg., not to exceed 1.6 µg/L any time; **Criterion to protect saltwater aquatic life:** not to exceed 0.07 µg/L; **Criterion to protect human health:** preferably 0; lifetime cancer risk level of 1 in 100,000: 0.0071 µg/L; Mexico set a MAC of 30 µg/L in estuaries, 3.0 µg/L in coastal waters, and 5.0 in receiving waters used for drinking water supply; drinking water standard set by EPA: 5.0 µg/L; the following are guidelines set by some states in drinking water: 5.0 µg/L (Maine), 0.3µg/L (Minnesota)

**PROBABLE FATE:** **photolysis:** not an important process; **oxidation:** probably not an important process; **hydrolysis:** too slow to be important; **volatilization:** may be an important process; **sorption:** is an important process; **biological processes:** bioaccumulation is an important process, biodegradation in anaerobic systems, but not in aerobic systems

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 3

**KEY REFERENCES:** 19; 21; 23; 25

### 1,2,4-TRICHLOROBENZENE (C<sub>6</sub>H<sub>3</sub>Cl<sub>3</sub>, 181.44)

**CAS/DOT IDENTIFICATION #:** 120-82-1/UN 2321

**SYNONYMS:** hostetex L-PEC, 1,2,5-trichlorobenzene, 1,3,4-trichlorobenzene, 1,2,4-trichlorobenzol

**PHYSICAL PROPERTIES:** colorless liquid; aromatic odor; slightly soluble in water; water solubility (48.8 mg/L @ 20 °C); sparingly soluble in alcohol; volatile with steam; MP (16 °C); BP (214 °C); SG (1.454); VD (>6 kg/m<sup>3</sup>); VP (1 mmHg @ 38 °C); OT (3 ppm); Log Kow (4.02); H (1.42 x 10<sup>-3</sup> atm-m<sup>3</sup>/mol)

**CHEMICAL PROPERTIES:** FP (110 °C); AT (570 °C); LEL/UEL (2.4%, 6.6%)

**BIOLOGICAL PROPERTIES:** T.O.C.: 0.005 mg/L; Koc: 1000-5000; moderate to high mobility in soil; biodegradation @ 0.1 mg/L: normal sewage: 0% after 24 hr and 135 hr, adapted sewage: 22% after 24 hr and 56% after 135 hr; degradation by *Pseudomonas*: 92% ring distribution at 30 °C of a 200 mg/L solution in 120 hr, mutant: 100% ring disruption in 46 hr; will not biodegrade in groundwater; slowly biodegrades in soil; can be detected in water by EPA Method 612: methylene chloride extraction followed by concentration, gas chromatography with electron capture detection and EPA Method 625: gas chromatography plus mass spectrometry; aerobic half-life: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months

**BIOACCUMULATION:** very high potential for bioaccumulation; bioconcentration in aquatic organisms ranges from 51 to 2,800; bluegill sunfish: 812; 8 species of fish: 124-1,300

**ORIGIN/INDUSTRY SOURCES/USES:** not a natural product; a product of hexachlorobenzene dechlorination by anaerobic sewage sludge; dye carrier; herbicide intermediates; degreaser; lubricant; synthetic transformer oils; insecticides; solvent in chemical manufacturing; in wood preservatives

**TOXICITY: Fish:** guppy (*Poecilia reticulata*): 14 d LC<sub>50</sub>: 2.4 ppm

**EXPOSURE ROUTES:** inhalation during manufacture and use; drinking water; food; contaminated fish

**REGULATORY STATUS:** MCLG: 0.07 mg/L; MCL: 0.07 mg/L; HAL(child): 1 day: 0.1 mg/L, longer term: 0.1 mg/L; no criterion developed due to insufficient data; **Criterion to protect freshwater aquatic life:** 210 µg/L/24 hr avg., concentration not to exceed 470 µg/L at any time; **Criterion to protect saltwater aquatic life:** 3.4 µg/L/24 hr avg., concentration not to exceed 7.8 µg/L at any time; the following are standards or guidelines in drinking water set by some states: 13 µg/L (Kansas), 8 µg/L (New Jersey)

**PROBABLE FATE: photolysis:** not subject to considerable direct photolysis, occurs slowly, sunlight photolysis in surface water at 40 deg latitude in summer has a reported half-life of 450 years; **oxidation:** oxidized by hydroxy radicals after volatilization; **hydrolysis:** not important process, first-order hydrolytic half-life: 3.4 years; **volatilization:** very rapid volatilization can be hindered by adsorption if organics are present; **sorption:** high potential for adsorption by organic materials; **biological processes:** high potential for bioaccumulation; very little, if any biodegradation due to volatilization and adsorption; **evaporation:** half-life from 5.4m deep seawater: 11-22 days; half-life from a model river: 4.2 hr predicted; in atmosphere, reacts with photochemically produced hydroxyl radicals with an approximate vapor phase half-life of 18.5 days.

**TREATABILITY/REMOVABILITY (Process, Removable Range (%), Avg. Achievable Conc. (µg/L)):** *Filtration*, 37, 94; *Sedimentation*, 0, negative removal; *Sedimentation with chemical addition (alum, lime)*, 91, 150; *Sedimentation with chemical addition (alum)*, 90, 150; *Activated sludge*, 67->99, 98; *Granular activated carbon adsorption*, >93, <0.04; best available technologies: granular activated charcoal and packed tower aeration

**KEY REFERENCES:** 19; 21; 22; 23; 24; 25; 26; 29

### 1,1,1-TRICHLOROETHANE (CH<sub>3</sub>CCl<sub>3</sub>, 133.4)

**CAS/DOT IDENTIFICATION #:** 71-55-6/UN 2831

**SYNONYMS:** arothene TT, chloroethene, chloroethane, chlorothene, inhibisol, methyl chloroform, methyltrichloromethane, solvent III, strobane, 1,1,1-TCE, α-trichloroethane

**PHYSICAL PROPERTIES:** clear, colorless liquid; miscible with acetone, benzene, methanol, and carbon disulfide; chloroform-like odor; very soluble in organic solvents; solubility in water (950 mg/L @ 20°C); MP (-30.4°C); BP (74.1°C); DN (1.3376 g/mL @ 20°C); SG (1.338); ST (25.4 dynes/cm); HV (-8012.7 cal/g mol); VS (0.858 cP @ 25°C); OT (44 ppm); VP (124 mmHg @ 25°C, 100 mmHg @ 20°C); Log Kow (2.17); H (4.92 x 10<sup>-3</sup> atm·m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** generally stable; will react violently with acetone, N<sub>2</sub>O<sub>4</sub>, liq. and gas. N<sub>2</sub>, aluminums, Na, and NaOH; LFL/UFL (8.0%, 10.5%); AT (537°C); HC (2600 cal/g)

**BIOLOGICAL PROPERTIES:** biodegradability not available; very slow degradation in subsoils; no degradation in river water found; BCF in bluegill sunfish is 8.9 in a 28 day test

**BIOACCUMULATION:** exhibit a greater bioconcentrating potential with increased chlorination; removed mainly in exhaled air; removed in urine; breakdown products detected in urine up to 12 days after exposure; stored in fat tissues temporarily; little inclination to bioconcentrate in fish; concentration found in fish tissues is higher than the concentration in the water the fish was taken

**ORIGIN/INDUSTRY SOURCES/USES:** not a natural product; wastewater discharges; stack fugitive emissions from production; volatilization losses from use in cold cleaning of metals; losses from vapor degreasing; solvent, aerosol spray; used in cleaning agents and pesticides

**TOXICITY: (Fish):** fathead minnow 96 hr LC<sub>50</sub> (F): 52.8 mg/L; fathead minnow 96 hr LC<sub>50</sub> (S): 105 mg/L; guppy 7 d LC<sub>50</sub>: 133 ppm

**EXPOSURE ROUTES:** industrial exposure; waste treatment plant discharges; spills; air emissions; wastewater from its production; major human exposure from air and drinking water

**REGULATORY STATUS: Criterion to protect freshwater aquatic life:** 5,300 µg/L—24 hr avg.; 12,000 µg/L—max. at any time; **Criterion to protect saltwater aquatic life:** 240 µg/L—24 hr avg.; 540 µg/L—max. at any time

**PROBABLE FATE: photolysis:** photodissociation to chlorine atoms and oxides in stratosphere is anticipated and leads to chemical's rapid degradation; **oxidation:** slow photooxidation in troposphere to trichloroacetaldehyde and afterward trichloroacetic acid is the predominant fate; **hydrolysis:** slow hydrolysis to acetic acid and hydrochloric acids and vinylidene chloride, with a half-life of 6 months; **volatilization:** rapid volatilization to the atmosphere and a major transport process; **sorption:** may be important fate mechanism; **biological processes:** some bioaccumulation and biodegradation indicated; **evaporation** from water @ 25°C of 1 ppm solution is 50% after 17-23 min and 90% after 63-80 min when released into surface water, pollutant will decrease in concentration due to evaporation; detected in finished surface water at 0.4 ppb median in 133 US cities; detected in finished groundwater at 2.1 ppb median in 23 US cities; when spilt on soil, volatilization and percolation into groundwater; **average U.S. background levels:** in soil: 0.42 ppb, in sediment: 0.45 ppb; when released in air, transports long distances and returns to earth in rain; half life less than 2 to 25 years

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, Not available, 50; *Gas floatation with chemical addition (calcium chloride, polymer)*, 22, 14; *Gas floatation with chemical addition (polymer)*, >4 - >9, <6; *Gas floatation with chemical addition (alum, polymer)*, 74, 860; *Filtration*, 67 - 94, 710; *Sedimentation*, 30 - >57, <19; *Sedimentation with chemical addition (alum, polymer)*, 46 - 93, 69; *Aerated lagoons*, 96, 22; *Steam stripping*, 9, 42,000; *Activated sludge*, 74 - >99, <2.4; *Granular activated carbon adsorption*, >99, <10;

**KEY REFERENCES:** 11,19,20,21,22,23,24,25,27

### 1,1,2-TRICHLOROETHANE (C<sub>2</sub>H<sub>3</sub>Cl<sub>3</sub>, 133.4)

**CAS/DOT IDENTIFICATION #:** 79-00-5/UN 2831

**SYNONYMS:** ethane trichloride, beta-T, beta-trichloroethane, vinyl trichloride, 1,1,2-trichlorethane

**PHYSICAL PROPERTIES:** clear, colorless liquid; sweet, chloroform-like odor; slightly soluble in water; solubility (4,500 mg/L @ 20°C); MP (-36.5°C); BP (113.7 °C); DN (1.435 g/cm<sup>3</sup> @ 20°C); SG (1.435); VD(4.55); VP (18.8 mmHg @ 20 °C); Log Kow (2.07); H (1.2 x 10<sup>-3</sup> atm-m<sup>3</sup>/mole @ 20°C); refractive index (1.4711 @ 20°C)

**CHEMICAL PROPERTIES:** nonflammable; stable under normal temperatures and pressures; reacts violently with Na, K, Mg, and Al; heat sensitive; incompatible with strong bases and strong oxidizing agents; LFL/UFL (8.4%, 13.3%); AT (460°C)

**BIOLOGICAL PROPERTIES:** biodegradation is unlikely, vinyl chloride suspected as a biodegradation product during anaerobic conditions; moderately to highly movable in soil; Koc values: 83-209; BCF: <1 in fish; surface water half-life: 4.5 months-1 year; groundwater half-life: 4.5 months-2 years; aerobic half-life: 6 months-1 year; anaerobic half-life: 2 years-4 years

**BIOACCUMULATION:** not predicted to bioconcentrate in fish with a log bioconcentration factor of <1; concentration found in fish tissues slightly higher than the concentration in the water from which the fish was taken

**ORIGIN/INDUSTRY SOURCES/USES:** release to water from alkalis and chlorine industries which use it as an intermediate in chemical manufacture; does not exist as a natural source; used as a solvent for: chlorinated rubbers, fats, oils, waxes, resins, alkaloids

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 93 mg/L, green algae (*Scenedesmus quadricauda*): 430 mg/L, protozoa (*Entosiphon sulcatum*): >1040 mg/L; **Toxicity (Fish):** guppy (*Poecilia reticulata*): 7 d LC50: 94 ppm; moderate toxicity to aquatic life

**EXPOSURE ROUTES:** ambient air near sources of emission; contaminated drinking water supplies

**REGULATORY STATUS:** Drinking water standards: MCLG: 0.003 mg/L, MCL: 0.005 mg/L, HAL (child): 0.6 mg/L in one day, 0.4 mg/L longer term; **Criterion to protect freshwater aquatic life:** 310 µg/L/ 24 hour avg., not to exceed 710 µg/L any time; **Criterion to protect saltwater aquatic life:** no criterion and insufficient data; concentration to keep the cancer risk level below 10<sup>-5</sup> is 2.7 µg/L

**PROBABLE FATE:** *photolysis:* no data for rate of photolysis in aquatic environment; *oxidation:* in aquatic systems not expected to be important fate, photooxidation in troposphere is probably the predominant fate; *hydrolysis:* expected to be slow, neutral aqueous hydrolysis half-life @ 25 °C: >50 years, first-order hydrolysis half-life: 37 years @ pH 7; *volatilization:* primary transport process, volatilization from soil will occur; *biological processes:* NA; *evaporation* from water @ 25 °C of 1 ppm solution is 50% after 21 min and 90% after 102 min; release to water primarily through evaporation (half-life: days to weeks); rate of evaporation half-life from water: 21 min; photodegrades slowly by reaction with hydroxyl radicals, half-life: 24-50 days in polluted atmosphere to a few days in unpolluted atmospheres; will be removed in rain

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *steam stripping*, >99, <48; *solvent extraction*, 90-95, 16,000; *activated sludge*, >9, <10, *granular activated carbon adsorption*, >99, <10; *Filtration* and *Sedimentation* indicated negative removal; best available technologies: granular activated charcoal, packed tower aeration

**KEY REFERENCES:** 19,21,22,23,24,25,26,27,28,29

**TRICHLOROETHENE (CHCl:CCl<sub>2</sub>, 131.38)****CAS/DOT IDENTIFICATION #:** 79-01-6/UN 1710

**SYNONYMS:** acetylene-trichloride, algylen, anameth, chlorilen, ethinyl-trichloride, ethylene-trichloride, fluate, germalgene, narcogen, narkosoid, threthylen, trichloroethylene, trichloro-ethane, triclene, trilen, trilene, trimar, uestrosol

**PHYSICAL PROPERTIES:** clear, colorless liquid; mobile; sweet odor of chloroform; immiscible with water; insoluble in water; soluble in most organic solvents; MP (-84°C); BP (86.7°C); DN (1.4649); SG (1.46); VP (60 mmHg @ 20°C); VD (4.53); VS (0.0055 poise); OT (28 ppm); solubility in water (1100 mg/L @ 20°C); Log Kow (2.42); H (11.7x10<sup>-3</sup> atm·m<sup>3</sup>/mole)

**CHEMICAL PROPERTIES:** nonflammable; slowly decomposes by light in the presence of moisture; FP (90°F); AT (788°F); LEL/UEL (8%, 10.5%)

**BIOLOGICAL PROPERTIES:** soil, surface water, and aerobic half-life: 6 months-1 yr; anaerobic half-life: 98 days-4.5 yrs; can be detected in water by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection, or EPA Method 624: gas chromatography plus mass

**BIOACCUMULATION:** the concentration found in fish tissues is expected to be somewhat higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** used as an extraction solvent in greases, oils, fats, waxes, and tars; degreaser of metal parts; chemical intermediate; refrigerant; typewriter correction fluids; paint removers/strippers; adhesives; spot removers; rug-cleaning fluids

**TOXICITY:** Toxicity threshold (cell multiplication inhibition test): bacteria (*Pseudomonas putida*): 65 mg/L, algae (*Microcystis aeruginosa*): 63 mg/L, green algae (*Scenedesmus quadricauda*): >1000 mg/L, protozoa (*Entosiphon sulcatum*): 1200 mg/L; protozoa (*Uronema parduczi* Chatton-L-woff): >960 mg/L

**EXPOSURE ROUTES:** ambient air; drinking water; ground water; air around factories where it is manufactured; use of products containing the chemicals; evaporation and leaching from waste disposal sites

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 45,000 µg/L based on acute toxicity; **Criterion to protect saltwater aquatic life:** 2,000 µg/L based on acute toxicity; **Criterion to protect human health:** preferably 0; lifetime cancer risk level of 1 in 100,000: 27 µg/L; Japan set a maximum permissible concentration in drinking water of 30 µg/L; USSR limit: 60 µg/L; WHO: 30 µg/L as a guideline; Mexico set a MAC of 30 µg/L in estuaries, 3.0 µg/L in coastal waters, and 5.0 in receiving waters used for drinking water supply; drinking water standard set by EPA: 5.0 µg/L; the following are guidelines set by some states in drinking water: 1.0 µg/L (New Jersey), 2.8µg/L (New Hampshire), 3.0 µg/L (Florida), 5.0 µg/L (California and Maine), 25 µg/L (Connecticut), 31.2 µg/L (Minnesota)

**PROBABLE FATE:** **photolysis:** tropospheric photooxidation of volatilized trichloroethylene by hydroxyl radicals to phosgene and dichloroacetyl chloride is very rapid, C-Cl bond can photolyze slowly; **oxidation:** not important except for photooxidation, photooxidation half-life in air: 1.1-11.3 days; **hydrolysis:** not important under environmental conditions, first-order hydrolytic half-life: 10.7 months; **volatilization:** rapid volatilization is the major transport process, evaporation from water @ 25°C of 1 ppm solution: 50% after 19-24 min, 90% after 63-80 min;

**sorption:** cannot compete with volatilization as a transport process; **biological processes:** evidence of bioaccumulation, but not magnification, exists; possible metabolization by higher organisms

**TREATABILITY/REMOVABILITY** (*Process*, Removable Range (%), Avg. Achievable Conc. ( $\mu\text{g/L}$ )): *Gravity oil separation*, not available, >71; *Gas flotation with chemical addition (calcium chloride, polymer)*, 43-86, 18; *Filtration*, 43->90, 31; *Sedimentation*, 35-71, 34; *Sedimentation with chemical addition (polymer)*, 0, negative removal; *Sedimentation with chemical addition (alum, polymer)*, 0, negative removal; *Sedimentation with chemical addition (alum)*, 10, 190; *Steam stripping*, 61->99, 16000; *Trickling Filters*, 0, negative removal; *Ozonation*, 0, negative removal; *Activated sludge*, 63->99, 9; *Granular activated carbon adsorption*, 29-58, 2.8; *Reverse osmosis*, 60, 0.4

**KEY REFERENCES:** 19; 21; 23; 25; 26; 31

## 2,4,6-TRICHLOROPHENOL ( $\text{C}_6\text{H}_2\text{Cl}_3\text{OH}$ , 197.44)

**CAS/DOT IDENTIFICATION #:** 88-06-2/UN NA-2020

**SYNONYMS:** dowicide-25, omal, phenachlor, trichloro-2-hydroxybenzene(1,3,5-)

**PHYSICAL PROPERTIES:** yellow flakes; strong phenolic odor; sweet smell; soluble in water, acetone, alcohol, ether; MP ( $69^\circ\text{C}$ ); BP ( $245^\circ\text{C}$ ); DN ( $1.4901 \text{ g/cm}^3$ ); SG (1.7); VP (1 mmHg @  $76.5^\circ\text{C}$ ); OT (0.0026 ppm); solubility (800 mg/L @  $25^\circ\text{C}$ ); Log Kow (3.38); H ( $6.14 \times 10^{-8} \text{ atm}\cdot\text{m}^3\cdot\text{mole}^{-1}$ ); Ka ( $3.8 \times 10^{-8}$  @  $25^\circ\text{C}$ )

**CHEMICAL PROPERTIES:** nonflammable; stable; incompatible with strong oxidizers; will not polymerize; no flash point

**BIOLOGICAL PROPERTIES:** decomposition in soil suspensions: 5 days for complete disappearance; degradation by *pseudomonas*: 100% ring distribution @  $30^\circ\text{C}$  of a 200 mg/L solution in 120 hr, mutant: 100% ring distribution in 50 hr; releases to water will biodegrade, photolyze, and adsorb to sediments; aerobic half-life: 7 days-70 days; anaerobic half-life: 169 days-5 years; half-life (soil): 7 days-70 days; half-life (surface water): 4 days; half-life (ground water): 14 days-5 yrs; can be detected in water by EPA Method: 604: methylene chloride extraction followed by gas chromatography with flame ionization or electron capture detection, or EPA Method 625: gas chromatography plus mass spectrometry

**BIOACCUMULATION:** BCF (at 10 ppm for fish): 20, Koc:  $2.0 \times 10^3$ ; bioaccumulation is important in some fish and snails; low to moderate bioaccumulation in other aquatic organisms

**ORIGIN/INDUSTRY SOURCES/USES:** germicide; bactericide; glue and wood preservative; antimildew treatment; manufacture of leather, pesticides; defoliant; produces 2,3,4,6-TCP and PCP

**TOXICITY:** organoleptic effects: 100  $\mu\text{g/L}$ ; goldfish: 24 hr  $\text{LC}_{50}$ : 10 ppm; amount found in dead fish @ 10 ppm: 200  $\mu\text{g/g}$ ; fathead minnows (*Pimephales promelas*): 96 hr TLm: 1.0-0.1 mg/L (static bioassay)

**EXPOSURE ROUTES:** primarily in water; detected in air; ingestion of food; pesticides; soil; wood; leather; wastewater; near hazardous waste sites; production sources of chlorinated

phenols or waste burners; glue preservatives; emissions from combustion of fuels; incineration of municipal waste

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** 970 µg/L based on chronic toxicity, 52 µg/L/24 hr avg., concentration not to exceed 150 µg/L any time; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0 µg/L; concentration calculated to keep the lifetime cancer risk level below  $10^{-5}$  is 12 µg/L based on organoleptic limits; the following are guidelines in drinking water set by some states: 17.0 µg/L(Kansas), 17.5 µg/L(Minnesota), 700.0 µg/L(Maine); WHO limit in drinking water: 10 µg/L

**PROBABLE FATE:** *photolysis:* reported in experiments, but environmental significance is unknown, aqueous photolytic half-life: 4 days, release to the environment can decrease due to photolysis and reaction with hydroxyl radicals; *oxidation:* too slow to be an important process, photooxidation half-life in water: 84.5 days, in air: 5.1-51.4 days; *hydrolysis:* not an important process; first-order hydrolytic half-life:  $>8 \times 10^6$  yrs; *volatilization:* not an important process, may contribute to losses at the surface of the soil; *sorption:* high potential for sorption by organic materials, rate is unknown; *biological processes:* biodegradation very important, but exact rate uncertain due to variations between data; *photomineralization:* may contribute to losses at the surface of the soil

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gas flotation with chemical addition (calcium chloride, polymer)*, 0, negative removal; *Filtration*, 80, 69; *Sedimentation*, 0, negative removal; *Aerated lagoons*, >99, <10; *Trickling Filters*, 0, negative removal; *Activated sludge*, 36-98, 450; *Powdered activated carbon adsorption* (based on synthetic wastewater), ~100, 90

**KEY REFERENCES:** 19; 21; 22; 23; 24; 25; 26

## VINYL CHLORIDE (CH<sub>2</sub>:CHCl, 62.50)

CAS/DOT IDENTIFICATION #: 75-01-4/UN 1086

**SYNONYMS:** chloroethene, chloroethylene, chloro-ethene, chloroethylene, ethene, chloro-, ethylene, chloro-, ethylene monochloride, monochloroethane, monochloroethylene

**PHYSICAL PROPERTIES:** colorless liquid or gas; faintly sweet odor; slightly soluble in water; soluble in alcohol and ether; MP (-160°C); BP (-13.9°C); DN (0.9195); VP (2600 mmHg @ 25°C); VD (2.15); OT (3000 ppm); solubility in water (1.1 mg/L @ 25°C); Log Kow (1.36)

**CHEMICAL PROPERTIES:** highly flammable; reacts with chemically active metals, aluminum and alloys, copper, and nitrogen oxides; FP (25°C); AT (882°F); LEL/UEL (4%, 22%)

**BIOLOGICAL PROPERTIES:** microbial degradation product of trichloroethylene in groundwater; soil, surface water, and aerobic half-lives: 4 weeks-6 months; anaerobic half-life: 16 weeks-24 months; ground water half-life: 8 weeks-95 months; can be detected in water by EPA Method 601: inert gas purge followed by gas chromatography with halide specific detection, or EPA Method 624: gas chromatography plus mass

**BIOACCUMULATION:** the concentration found in fish tissues is expected to be about the same as the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** polyvinyl chloride; plastics; vinyl products; refrigerant gas; manufacture of other chemicals; solvent

**TOXICITY:** insufficient data

**EXPOSURE ROUTES:** ambient air; discharge of exhaust gases; evaporation where chemical wastes are stored; air inside new cars; drinking water; water in contact with polyvinyl pipes; adsorbed by inhalation

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** preferably 0; lifetime cancer risk of 1 in 100,000: 20 µg/L; longtime health advisory: 46 µg/L set by EPA; the following are guidelines set by some states in drinking water: 0 µg/L (Rhode Island), 0.15µg/L (Minnesota), 1.0 µg/L (Arizona, Florida, Kansas, Massachusetts, New Mexico, and Vermont), 2.0 µg/L (California, Maine, and New Jersey), 5.0 µg/L (New York)

**PROBABLE FATE:** **photolysis:** light-induced transformations can occur through indirect photolysis in water containing photosensitizers, direct photolysis is insignificant; **oxidation:** decomposed in water by reactive radicals when present in sufficient concentration, in the troposphere rapid oxidation by hydroxyl radicals occurs yielding hydrogen chloride and carbon monoxide as end products, photooxidation half-life in air: 9.7-97 hrs; **hydrolysis:** due to rapid volatilization, hydrolysis should not be a significant aquatic fate; **volatilization:** volatilization to the atmosphere is rapid and is a major transport process, evaporation from water @ 25°C of 1 ppm solution: 50% after 26 min, 90% after 96 min.; **sorption:** sorption by inorganic and organic materials not expected to be important fate mechanism; **biological processes:** biodegradation and bioaccumulation are not believed to be important fate processes; **other reactions/interactions:** can be converted to more highly chlorinated compounds in aqueous environment in aqueous environment where high concentrations of chlorine/chloride exist

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Granular activated carbon adsorption*, 0, negative removal

**KEY REFERENCES:** 19; 21; 23; 25; 26; 27

## ZINC (Zn, 65.38)

**CAS/DOT IDENTIFICATION #:** 7440-66-6/UN 1383 and 1436

**SYNONYMS:** blue powder, C.I. pigment-black 16

**PHYSICAL PROPERTIES:** MP (420°C); BP 907°C); VP (negligible)

**CHEMICAL PROPERTIES:** combines with other elements to form zinc compounds

**BIOLOGICAL PROPERTIES:** attaches to soil, sediments, and dust particles in the air; can move into the groundwater and into lakes, streams, and rivers; most of the zinc in soil stays bound to soil particles

**BIOACCUMULATION:** builds up in fish and other organisms, but not in plants; concentration found in fish tissues is expected to be considerably higher than the concentration in the water from which the fish were taken

**ORIGIN/INDUSTRY SOURCES/USES:** protective coating of other metals; alloy for electrical apparatus; organic chemical extractions and reductions

**TOXICITY:** high chronic toxicity to aquatic life

**EXPOSURE ROUTES:** air; soil; water; present in all foods; mining; steel production; coal burning; burning of waste

**REGULATORY STATUS:** **Criterion to protect freshwater aquatic life:** insufficient data; **Criterion to protect saltwater aquatic life:** insufficient data; **Criterion to protect human health:** 5 mg/L set by EPA based on organoleptic properties; standards set include: for drinking water: Germany: 2,000 µg/L, USSR: 1,000 µg/L, in estuaries: Mexico: 10,000 µg/L, for coastal waters: Mexico: 10 µg/L, for surface water: USSR: 1,000 µg/L, in water for fishery purposes: USSR: 10 µg/L, in water for esthetic quality: WHO: 5,000 µg/L; Kansas has set a drinking water limit of 5 mg/L

**PROBABLE FATE:** **photolysis:** not important; **oxidation:** ZnS precipitates under reducing conditions, most redox conditions do not affect Zn directly, but may affect materials which sorb Zn; **hydrolysis:** Zn(OH)<sub>2</sub> and ZnO precipitate after formation by hydrolysis; **volatilization:** not important; **sorption:** dominant fate of Zn is sorption by hydrous metal oxides, clay minerals, and organic materials; **biological processes:** strongly bioaccumulated in all organisms and biotransformed to many zinc-containing enzymes

**TREATABILITY/REMOVABILITY** (*Process, Removable Range (%)*, Avg. Achievable Conc. (µg/L)): *Gravity oil separation*, not available, 390; *Gas flotation*, 11-22, 22,000; *Gas flotation with chemical addition (calcium chloride, polymer)*, >95->99, 150; *Gas flotation with chemical addition (polymer)*, >38->60, 120; *Gas flotation with chemical addition (alum, polymer)*, 10, 2300; *Filtration*, 39->99, 150; *Sedimentation*, 71->99, 2,600; *Sedimentation with chemical addition (alum, lime)*, 55->99, 3400; *Sedimentation with chemical addition (lime, polymer)*, 84->99, 410; *Sedimentation with chemical addition (Fe<sup>2+</sup>, lime)*, >79->97, 12; *Sedimentation with chemical addition (sulfide)*, >98->99, 140; *Sedimentation with chemical addition (polymer)*, 84-97, 2400; *Sedimentation with chemical addition (BaCl<sub>2</sub>)*, 65-80, 30; *Sedimentation with chemical addition (alum, polymer)*, 69-83, 660; *Sedimentation with chemical addition (alum)*, 69-83, 3800; *Sedimentation with chemical addition (lime)*, 77->99, 640; *Aerated lagoons*, 55->99, 180; *Ultrafiltration*, >78-98, 8600; *Ozonation*, 32-96, 260; *Ion exchange*, 97, 400; *Activated sludge*, 35-92, 200; *Granular activated carbon adsorption*, 40->99, 440; *Reverse osmosis*, 83->99, 530

**KEY REFERENCES:** 21; 23; 27; 31

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

**ACETALDEHYDE (C<sub>2</sub>H<sub>4</sub>O, 44.06)****CAS/DOT IDENTIFICATION #:** 75-07-0/UN1089**SYNONYMS:** acetic aldehyde, ethanal, ethyl aldehyde

**PHYSICAL PROPERTIES:** mobile, colorless liquid; pungent, suffocating odor, but has a fruity and pleasant odor at dilute concentrations; leafy, green taste; miscible with water, alcohol, ether, benzene, gasoline, toluene, xylene, turpentine, and acetone; MP (-123.5°C, -190.3°F); BP (21°C, 70°F); DN (0.788g/mL at 16°C); ST (29.04 dynes/cm at 20°C); VS (0.02456mPa at 20°C); HV (136 cal/g); VD (1.52); VP (740mmHg at 20°C); OT (0.21ppm); CP (89.0 J/mol-K, liquid at 298.15K).

**CHEMICAL PROPERTIES:** reacts with oxidizers, halogens, amines, strong bases, and acids; FP (-8°C,-36°F); LFL/UFL (4.0%, 60%); AT (365°C); SH (0.650); HC (-246.4 x 105J/kg); HF (-191.8 kJ/mol liquid at 298.15K).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; NFPA rating Health 2, Flammability 4, Reactivity 2; oxidizes readily in air to unstable peroxides that may explode spontaneously; condensation reaction with acid anhydrides, alcohols, ketones, and phenols can be violent; combination with bromine, chlorine, fluorine, or iodine can be violent; reaction of anhydrous ammonia, hydrogen cyanide, or hydrogen sulfide can be violent; use carbon dioxide, dry chemical powder, or appropriate foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); skin absorption (respiratory system, narcosis, nausea, loss of consciousness).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin promptly with water; provide respiratory support; if swallowed, get immediate medical attention.

**HUMAN TOXICITY DATA:** inhalation-human TCL0 134ppm/30M; eye-human 50ppm/15M; EPA Cancer Risk Level (1 in a million excess lifetime risk): 5.0 x 10<sup>-4</sup> mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory tract; erythema; coughing; pulmonary edema; necrosis; respira-tory paralysis; death in high exposures.

**CHRONIC HEALTH RISKS:** symptoms of chronic intoxication in humans resemble those of alcoholism; long-term inhalation exposure in hamsters has produced changes in the nasal mucosa and trachea, growth retardation, slight anemia, and increased kidney weight; re-productive/developmental effects; EPA Group B2; probable human carcinogen of low carcinogenic hazard.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100ppm; ACGIH STEL 150ppm; OSHA PEL TWA 200ppm (360 mg/m<sup>3</sup>); IDLH 2000ppm.

**PERSONAL PROTECTION:** wear special protective clothing and appropriate eye protection; positive pressure self-contained breathing apparatus is recommended at concentrations above the REL.

**SPILL CLEAN UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; control runoff and isolate discharged material for proper disposal; eliminate all ignition sources.

**DISPOSAL AND STORAGE METHODS:** store in a cool, dry, well-ventilated location separate from other reactive hazards, inside should be in a standard flammable liquids storage room or cabinet; store bulk quantities in detached tanks provided with refrigeration and inert gas cover; for small quantities absorb on paper towels, if in liquid form; evaporate in safe place, then

burn the paper in a location away from combustible materials; large quantities can be collected and atomized in a suitable combustion chamber.

**REGULATORY INFORMATION:** CA2, F2, R6, U waste # (U001); Reportable Quantity (RQ): 1000 lbs (454 kg); Sf1; Sf3; CW1; CW2; T30-e1; T120-d1; Al; A5; CAL. DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of acetic acid, butanol, perfumes, plastics, synthetic rubber, etc.; flavoring agent in foods and beverages; dangerous to aquatic life in low concentrations.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 13.

### **ACETIC ACID (C<sub>2</sub>H<sub>4</sub>O<sub>2</sub>, 60.06)**

**CAS/DOT IDENTIFICATION #:** 64-19-7/UN2789

**SYNONYMS:** ethanoic acid, methane carboxylic acid, vinegar acid

**PHYSICAL PROPERTIES:** clear, colorless liquid or crystals; pungent, vinegar-like odor; miscible with water, alcohol, glycerol, ether, carbon tetrachloride, acetone, and benzene; insoluble in carbon disulfide; MP (16.6°C, 62°F); BP (118°C, 244°F); SG (1.05); DN (1.049 g/ml at 20°C); ST (28.8 dynes/cm at 10°C); VS (1.22cP at 20°C); CP (123.3 J/mol-K liquid at 298.15K); HV (9.963.9 gcal/gmole); VD (2.07); VP (11mmHg at 20°C); OT (0.21 to 1.0ppm).

**CHEMICAL PROPERTIES:** reacts vigorously with strong oxidizers (especially chromic acid, sodium peroxide, and nitric acid); corrosive to metals; FP (43°C, 110°F); LFL/UFL(4.0%, 16.0%); AT (426°C, 800°F); HC (209.02 kcal/gmole at 25°C); HF (-484.5 kJ/mol at 298.15K).

**EXPLOSION and FIRE CONCERNS:** a highly flammable liquid; NFPA rating Health 2, Flammability 2, Reactivity 1; vapors form explosive mixtures with air; explosive reactions with bromine pentafluoride, chromium trioxide, hydrogen peroxide, potassium permanganate, sodium peroxide; ignites on contact with potassium-tert-butoxide; incompatible or reacts violently with acetaldehyde, acetic anhydride, chromic acid, nitric acid, ammonium nitrate, chlorine trifluoride, (nitric acid + acetone), perchloric acid, potassium hydroxide, sodium hydroxide, xylene; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and nose, irritating to respiratory system); skin and/or eye contact (conjunctivitis, dermatitis, dental erosion).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human TDLo 1470 mg/kg; in-halation-human TCLo 816ppm/3M; skin-human 50 mg/24H.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, nose, and throat; skin burns; skin sensitization; inflammation of mucous membranes.

**CHRONIC HEALTH RISKS:** chronic bronchitis; dermatitis; conjunctivitis; lacrimation (discharge of tears); pharyngeal edema; hyper-keratosis; black skin; dental erosion.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm (25 mg/m<sup>3</sup>); ACGIH STEL 15ppm (37 mg/m<sup>3</sup>); OSHA PEL TWA 10ppm (25 mg/m<sup>3</sup>); NIOSH REL TWA 10ppm (25 mg/m<sup>3</sup>); NIOSH STEL 15ppm (37 mg/m<sup>3</sup>); IDLH 50ppm.

**PERSONAL PROTECTION:** protective clothing of rubber or similar non-permeable material; wear chemical safety goggles; in high vapor concentrations, wear any self-contained breathing apparatus with a full facepiece.

**SPILL CLEAN-UP:** absorb bulk liquid with fly ash or cement powder; neutralize with caustic soda or soda ash; dilute spills to form non-flammable mixtures and isolate discharged material for proper disposal.

**DISPOSAL AND STORAGE METHODS:** store in a dry, well-ventilated place; separate from oxidizing materials and alkaline substances; solid acid may be packaged in paper and burned in incinerator.

**REGULATORY INFORMATION:** F2; Sfl; CW1; CW2; A1; CAL; DOT hazard class/division (8); labels (corrosive, flammable liquid); Reportable Quantity (RQ): 1000 lbs (454 kg).

**OTHER COMMENTS:** used in manufacturing acetic anhydride, cellulose acetate, chloroacetic acid; production of plastics, pharmaceuticals, dyes, food additives; textile printing.

**KEY REFERENCES:** 4; 5; 6; 10; 11; 12; 13.

### **ACETIC ANHYDRIDE (C<sub>4</sub>H<sub>6</sub>O<sub>3</sub>, 102.10)**

**CAS/DOT IDENTIFICATION #:** 108-24-7/UN1715

**SYNONYMS:** acetic acid anhydride; acetyl oxide; ethanoic anhydride

**PHYSICAL PROPERTIES:** colorless, very mobile, strongly refractive liquid; very strong, irritating acetic odor; miscible with ethanol, ether, and acetic acid; soluble in cold water; soluble in alcohol, chloroform, ether, benzene; MP (-74°C, -101°F); BP (139°C, 282°F); SG (1.08); DN (1.082g/ml at 20°C); ST (32.7 dynes/cm at 20°C); VS (0.971cP at 15°C); HV (119 Btu/lb, 66.2 cal/g, 2.77 x 10<sup>5</sup>J/kg); VD (3.52); VP (1mm Hg at 1.7°C, 4mm Hg at 20°C, 10mm Hg at 36°C); OT (0.13uL/L).

**CHEMICAL PROPERTIES:** reacts vigorously with strong oxidizers (especially chromic acid), water, alcohols, and amines; reacts with water to form acetic acid; corrosive to metals; FP (52°C, 126°F); LFL/UFL(2.9%, 10.3%); AT (385°C, 732°F); HC (431.70 kg cal/gmole at 25°C); HF (-624.4 kJ/mol liquid at 298.15K).

**EXPLOSION and FIRE CONCERNS:** a flammable liquid; NFPA rating Health 2, Flammability 2, Reactivity 1; explosive reactions with barium peroxide, boric acid, hydrochloric acid + water, potassium permanganate; incompatible with 2- amino ethanol, aniline, glycerol, hydrogen fluoride, permanganates, sodium hydroxide, sodium peroxide, sulfuric acid, water; when heated to decomposition it emits toxic fumes such as acetic acid and carbon monoxide; use carbon dioxide, dry chemical, water mist, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat, nausea, vomiting, difficult breathing); skin absorption (respiratory system, skin burns, sensitization dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with plenty of water; provide respiratory support; if swallowed, do not induce vomiting and get medical care quickly.

**HUMAN TOXICITY DATA:** no information available on effects on humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes and upper respiratory system; conjunctivitis; lacrimation; corneal edema; opacity and photophobia; nasal, pharyngeal irritation; coughing; dyspnea; bronchitis.

**CHRONIC HEALTH RISKS:** skin burns; vesiculation; sensitization dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV (ceiling level) 5ppm; ACGIH TLV TWA 5ppm; OSHA PEL TWA 5ppm (10 mg/m<sup>3</sup>); NIOSH REL (ceiling level) 5ppm (20 mg/m<sup>3</sup>); IDLH 200ppm.

**PERSONAL PROTECTION:** wear special protective rubber-coated clothing or other impermeable materials; wear chemical safety goggles, face shield; wear positive pressure self-contained breathing apparatus (equipment should be acid resistant).

**SPILL CLEAN-UP:** absorb small quantities on paper towels; use water spray to cool and disperse vapors, protect personnel, and dilute spills to form nonflammable mixtures; neutralize spill and washings with soda ash or lime; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** mix with flammable solvent and inject at base of incinerator with after-burner; solid acid may be packaged in paper and burned in incinerator; store in a cool, dry, well-ventilated location; store away from heat, oxidizers, and sunlight; outside or detached storage preferred.

**REGULATORY INFORMATION:** Sfl; CW1; CW2; A1; CAL; DOT hazard class/division (8); labels (corrosive, flammable liquid); Re-portable Quantity (RQ): 5000 lbs (2270 kg).

**OTHER COMMENTS:** used in manufacture of synthetic fibers, plastics, explosives, resins, perfumes, flavorings, textile industry; pharmaceutical and pesticide intermediate.

**KEY REFERENCES:** 4; 5; 6; 7; 11; 12.

## **ACETONE (C<sub>3</sub>H<sub>6</sub>O, 58.09)**

**CAS/DOT IDENTIFICATION #:** 67-64-1/UN1090

**SYNONYMS:** dimethyl ketone, ketone propane, 2-propanone

**PHYSICAL PROPERTIES:** colorless liquid with a fragrant, mint-like odor; soluble in benzene; miscible with water, alcohol, dimethyl-formamide, ether, chloroform, most oils; MP (-94.3°C, -137.7°F); BP (56.2°C, 133°F); SG (0.79); DN (0.7972g/ml at 15°C); ST (26.2mN/m at 0°C, 23.7mN/m at 20°C, 18.7mN/m at 60°C); VS (0.306mPa·s at 298.15K); CP (126.3J/K mol liquid at 298.15K); HV (220 Btu/lb, 122 cal/g); VD (2.00); VP (180mmHg at 20°C); OT (water (20ppm)); air (13ppm)).

**CHEMICAL PROPERTIES:** reacts violently with bromoform, chloroform + alkalis, bromine, and sulfur dichloride; FP (0°F); LFL/UFL(2.6%, 12.8%); AT (537°C, 1000°F); HC liquid (-1787 kJ/mol, -427 kcal/mol); HF (-248.1 kJ/mol liquid at 298.15K).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 0; explosive reaction with nitric acid + sulfuric acid, bromine trifluoride, hydrogen peroxide; ignites on contact with activated carbon, chromium trioxide, potassium-tert-butoxide; reacts violently with bromoform, chloroform + alkalies, bromine; incompatible with air, nitric acid, chloroform, and sulfuric acid; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, throat and acts as an anesthetic in very high concentrations); ingestion (headache, dizziness, irritating to mucous membranes); skin absorption (defatting of skin, dermatitis).

**FIRST AID:** flush eyes immediately with large amounts of water for at least 15-min.; wash skin immediately with soap and water; if swallowed, induce vomiting; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLO 500ppm; eye-human TCLO 500ppm.

**ACUTE HEALTH RISKS:** conjunctiva irritation; nasal effects; respiratory system effects; nausea; vomiting; muscle weakness; metabolic changes; changes in EEG; kidney damage; coma.

**CHRONIC HEALTH EFFECTS:** irritation of eyes, nose and throat; headache, dizziness; dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 750ppm; ACGIH STEL 1000ppm; OSHA PEL TWA 750ppm; OSHA STEL 1000ppm (2400 mg/m<sup>3</sup>); NIOSH REL TWA 250ppm (590 mg/m<sup>3</sup>); IDLH 2500ppm (10% LEL).

**PERSONAL PROTECTION:** respiratory apparatus should be employed if vapors are concentrated enough to cause irritation; use protective equipment and clothing made from natural rubber, neoprene, polyvinyl alcohol; wear chemical safety goggles with or without face shield.

**SPILL CLEAN-UP:** absorb as much as possible on paper; burn the paper; wash away remaining acetone with copious amounts of water; evaporate on a glass or iron dish in hood; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** small amounts can be burned after pouring on dry sand; larger quantities can be atomized in an approved type combustion chamber.

**REGULATORY INFORMATION:** S10; R2-16; R3; R5; U waste # (U002); Reportable Quantity (RQ): 5000 lbs (2270 kg); Sf1; T799-5000; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of explosives, air-plane dopes, rayon, photographic films; in paint varnish and removers; nail polish remover; used in the preparation of vitamin intermediates; pharmaceutical aid.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 11; 12; 13.

**ACETONITRILE (C<sub>2</sub>H<sub>3</sub>N, 41.06)**

**CAS/DOT IDENTIFICATION #:** 75-05-8/UN1648

**SYNONYMS:** cyanomethane, ethanenitrile, methyl cyanide

**PHYSICAL PROPERTIES:** colorless, limpid liquid; aromatic, ether-like odor; burning, sweetish taste; very soluble in ethyl alcohol; freely soluble in water; miscible with water, methanol, benzene, acetone, ether, chloroform, carbon tetrachloride, and many unsaturated hydrocarbons; immiscible with many saturated hydrocarbons; MP (-46°C, -50°F); BP (82°C, 179°F); SG (0.79); DN (0.78745g/mL at 15°C); ST (29.04 dynes/cm at 20°C); VS (0.43cP at 0°C, 0.25cP at 20°C, 0.30cP at 40°C); CP (91.4 J/K mol liquid at 298.15K); HV (313 Btu/lb, 174 cal/g, 7.29 x 10<sup>5</sup> J/kg); VD (1.42); VP (73mm at 20°C, 100mm at 27°C); OT (70.0 mg/m<sup>3</sup>, irritating).

**CHEMICAL PROPERTIES:** chemical action will slowly release cyanides; toxic vapors generated when heated; reacts violently with strong oxidizers; dissolves somewhat in inorganic salts; will attack some forms of plastics, rubber, and coatings; heat contributes to instability; FP (5°C, 42°F); LFL/UFL(4.4%, 16.0%); AT (522°C, 973°F); HC (-13.360 Btu/lb, -420 cal/g, -10.7 x 10<sup>5</sup> J/kg); HF (31.4 kJ/mol liquid at 298.15K).

**EXPLOSION and FIRE CONCERNS:** dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 0; explosive reaction with lanthanide perchlorates and nitrogen-fluorine compounds; reacts with water, steam, and acids to produce toxic and flammable vapors; incompatible with chlorosulfonic acid, nitric acid, sulfur trioxide; use foam, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, respiratory system); skin absorption (nausea, vomiting, chest pain).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with water; if swallowed and victim is conscious, have victim drink water, or milk; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human TDLO 570 mg/kg; inhalation-human TCLO 160ppm/4H.

**ACUTE HEALTH RISKS:** irritation of mucous membranes; irritation of nose, throat; asphyxia; nausea; vomiting; chest pain; weakness, stupor; convulsions; paralysis; liver, kidney damage, death.

**CHRONIC HEALTH RISKS:** cyanide poisoning from metabolic release of cyanide after absorption; headaches; numbness; tremor; dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 40ppm; ACGIH STEL 60ppm; OSHA PEL TWA 40ppm (70 mg/m<sup>3</sup>); OSHA STEL 60ppm; NIOSH REL TWA 20ppm (34 mg/m<sup>3</sup>); IDLH 500ppm.

**PERSONAL PROTECTION:** wear positive pressure self-contained breathing apparatus; wear impervious clothing, gloves, face shields, etc.; wear splash-proof safety goggles.

**SPILL CLEAN-UP:** remove all ignition sources; use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; absorb small quantities on paper towels; burn paper away from combustible materials; collect large quantities and atomize in suitable combustion chamber with appropriate effluent gas cleaning device.

**DISPOSAL AND STORAGE METHODS:** add with stirring to strong alkaline solution of calcium hypochlorite; let stand 24 hours, route to sewage plant; dissolve in flammable solvents and spray into incinerator with afterburner and scrubber; outside storage preferred; store in cool, dry, well-ventilated location; isolate from oxidizing gases, especially chlorine.

**REGULATORY INFORMATION:** CA2; R3; R4; R5; R6; R8; U waste # (U003); Reportable Quantity (RQ): 5000 lbs (2270 kg); Sf1; Sf3; T120-a; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent in the manufacture of pharmaceuticals; used in dyeing textiles and in perfume production as a chemical intermediate; dangerous to aquatic life in high concentrations.

**KEY REFERENCES:** 1; 3; 4; 5; 6; 7; 10; 11; 12.

## **2-ACETYLAMINOFLUORINE (C15H13NO, 223.29)**

**CAS/DOT IDENTIFICATION #:** 53-96-3/none reported

**SYNONYMS:** AAF, 2-AAF, 2-Acetaminofluorene; N-2-fluorenylacetamide.

**PHYSICAL PROPERTIES:** tan, crystalline powder; insoluble in water; soluble in alcohols, glycols, fat solvents; MP (192-196°C, 378-385°F); BP (NA); SG (NA); VP (NA).

**CHEMICAL PROPERTIES:** stable under normal temperatures and pressures; incompatible with acids, acid anhydrides, and oxidizing agents; FP (NA); LFL/UFL(NA).

**EXPLOSION and FIRE CONCERNS:** when heated to decomposition, emits toxic fumes of NO<sub>x</sub>; incompatible or reacts with acids, acid anhydrides, and oxidizing agents; forms hazardous decomposition products such as nitrogen oxides, carbon dioxide, carbon monoxide, hydrogen fluoride, nitrogen; use dry chemical, water spray or mist, chemical foam, or alcohol-resistant foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin); skin absorption (reduced function of liver, kidneys, bladder, pancreas).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** dnd-human fbr 1mmol/L; Sce-human lym 4400 ug/L.

**ACUTE HEALTH RISKS:** reduced function of liver, kidneys, bladder and pancreas.

**CHRONIC HEALTH RISKS:** lung irritation, irritation of skin.

**EXPOSURE GUIDELINES:** NIOSH REL TWA use 29 CFR 1910.1014; OSHA PEL cancer suspect agent.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus; wear chemical safety goggles and other protective clothing.

**SPILL CLEAN-UP:** for small quantities, absorb on paper towels; for large quantities, may be absorbed on dry earth; cover with lime or soda ash; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** contact DEP or regional office of EPA for specific recommendation for disposal; regulated numbered area should be established; do not store near smokey or open flame.

**REGULATORY INFORMATION:** CA2; R3; R4; R5; U waste # (U005); Reportable Quantity (RQ): 1.0 lb (0.45 kg); Sf1; Sf3; A1; A4; CAL.

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**OTHER COMMENTS:** used in the laboratory by biochemists in the study of liver enzymes; carcinogenesis of aromatic amines; mutagenicity of aromatic amines.

**KEY REFERENCES:** 4; 5; 12; 13; 14.

### ACETYLENE TETRABROMIDE (C<sub>2</sub>H<sub>2</sub>Br<sub>4</sub>, 345.7)

**CAS/DOT IDENTIFICATION #:** 79-27-6/UN2504

**SYNONYMS:** Muthmann's liquid, TBE, Tetrabromoethane, 1,1,2,2-Tetrabromoethane

**PHYSICAL PROPERTIES:** heavy, colorless to pale yellow liquid; pungent odor similar to camphor and iodoform (sweet, medicinal); insoluble in water; miscible with alcohol, chloroform, ether, aniline, glacial acetic acid; MP (0°C, 32°F); BP (151°C at 54mm Hg, 239-242°C with decomposition); SG (2.97); DN (2.964g/ml at 20°C); HV (70 kJ/mol at 298.15K); VF (0.02mm Hg at 20°C).

**CHEMICAL PROPERTIES:** reacts with oxidizing materials and alkalis; incompatible with reducing metals such as aluminum, magnesium and zinc; FP (NA); LFL/UFL(NA); AT (635°F).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating Health 3, Flammability 0, Reactivity 1; decomposes at 374°F (190°C) to liberate flammable and highly toxic vapors of carbonyl bromide and Br<sup>-</sup>; incompatible or reacts strongly with strong caustics, hot iron, and reducing metals such as aluminum, magnesium and zinc; use suitable agent for fire-fighting purposes and water spray to cool fire exposed containers.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, and respiratory system); skin absorption (nausea, dizziness, headache, abdominal pain, jaundice).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with water promptly; provide respiratory support.

**HUMAN TOXICITY DATA:** no information available on effects on humans.

**ACUTE HEALTH RISKS:** irritation of eyes and nose; nausea; severe headaches; abdominal pain; jaundice.

**CHRONIC HEALTH RISKS:** CNS depression; monocytosis; anorexia.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm; OSHA PEL TWA 1ppm (14 mg/m<sup>3</sup>); IDLH 8ppm.

**PERSONAL PROTECTION:** wear positive pressure self-contained breathing apparatus; wear special protective clothing; wear splash-proof safety goggles.

**SPILL CLEAN-UP:** approach release from upwind; use appropriate foam to blanket release and suppress vapors; absorb in noncombustible material for proper disposal.

**DISPOSAL AND STORAGE METHODS:** store in a cool, dry, well-ventilated location; separate from oxidizing materials and alkalis; control runoff and isolate for proper disposal.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used for separating minerals by specific gravity; used as a solvent for fats, oils, and waxes; also used as a fluid in liquid gauges and as a solvent in microscopy.

**KEY REFERENCES:** 4; 5; 7; 9; 10; 11; 12.

### **ACROLEIN (C-3H4O, 56.07)**

**CAS/DOT IDENTIFICATION #:** 107-02-8/UN1092

**SYNONYMS:** acrylaldehyde, acrylic aldehyde, 2-propenal

**PHYSICAL PROPERTIES:** clear, colorless to yellowish liquid; disagreeable, choking odor; soluble in water, alcohol, ether; MP (-88°C, 126°F); BP (53°C, 127°F); SG (0.84); DN (0.8389g/ml at 20°C, 0.8621 at 0°C); ST (24 dynes/cm = 0.024 N/m at 20°C); VS (0.393cP at 20°C); HV (216 Btu/lb, 120 cal/g, 5.02 x 105J/kg); VD (1.94); VP (210mmHg at 20°C, 135.71mmHg at 10°C, 325.70mmHg at 30°C, 692.15mmHg at 50°C); OT (0.21ppm).

**CHEMICAL PROPERTIES:** reacts vigorously with oxidizing materials; polymerization reaction on contact with strong acid, strong base, weak acid conditions (e.g., nitrous fumes, sulfur dioxide, carbon dioxide); may form shock sensitive peroxides or acids; FP (-26°C, -15°F); LFL/UFL(2.8%, 31%); AT (235°C, 455°F); HC (-12,500 Btu/lb, -6,950 cal/g, -290 x 105J/kg).

**EXPLOSION and FIRE CONCERNS:** dangerous fire hazard; NFPA rating Health 3, Flammability 3, Reactivity 2; polymerizes violently on contact with strong acid, strong base, weak acid conditions, and dimethylamine; incompatible or reacts vigorously with strong oxidizers, amines, sulfur dioxide, and metal salts; when heated to decomposition, emits highly toxic gases and vapors (such as carbon monoxide and peroxides); use carbon dioxide, dry chemical, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes, skin and pulmonary edema); skin absorption (nausea, vomiting, respiratory system).

**FIRST AID:** flush eyes and/or skin immediately with large amounts of water for 15 minutes; if ingested, drink large amounts of water and induce vomiting; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 5500ppb; inhalation-human LCLo 153ppm/10M; eye-human 500ppb/12M.

**ACUTE HEALTH RISKS:** irritation of skin, eyes and upper respiratory tract; destructive to tissue of the mucous membranes; inflammation of larynx and bronchi; pulmonary edema; chemical pneumonitis; coughing; laryngitis; wheezing; shortness of breath; headache; nausea; vomiting; allergic skin reaction.

**CHRONIC HEALTH RISKS:** eye, nose, and throat irritation; damage to cardiovascular system; liver and kidney damage; chronic respiratory disease.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1ppm; ACGIH STEL 0.3ppm; OSHA PEL TWA 0.1ppm (0.25 mg/m<sup>3</sup>); OSHA STEL 0.3ppm; NIOSH REL TWA 0.1ppm (0.25 mg/m<sup>3</sup>); NIOSH STEL 0.3ppm (0.8 mg/m<sup>3</sup>); IDLH 2ppm.

**PERSONAL PROTECTION:** wear clothing made of rubber, rubber safety shoes, and chemical resistant gloves; wear chemical safety goggles and face shield; wear self-contained breathing apparatus.

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**SPILL CLEAN-UP:** absorb small quantities on paper towels and evaporate in fume hood; burn the paper; for large quantities, cover with sodium bisulfite and flush with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb on vermiculite and burn in open incinerator; addition of  $\text{KMnO}_4$  will break down to acid, which can be routed to sewage treatment plant; outside storage preferred; inside storage should be in a standard flammable liquids storage room or cabinet; separate from oxidizing materials, peroxides, acids, and alkalis.

**REGULATORY INFORMATION:** CA2; F1; R3; R4; R5; R6; R8; P waste # (P003) Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; Sf2; Sf3; CW1; CW2; CW3; CW4; CW5; A1 A4; CAL; DOT hazard class/division (6.1); labels (flammable liquid, poison).

**OTHER COMMENTS:** used in the manufacture of pesticides, plastics, perfumes, glycerin, acrylic acid, esters.

**KEY REFERENCES:** 2; 3; 5; 6; 10; 11; 12; 13.

### ACRYLAMIDE (C-3H5NO, 71.09)

**CAS/DOT IDENTIFICATION #:** 79-06-1/2074

**SYNONYMS:** acrylic amide, 2-propenamide, vinyl amide

**PHYSICAL PROPERTIES:** white, crystalline solid; leaf crystal from benzene; odorless; very soluble in water, alcohol, and ether; MP ( $85^\circ\text{C}$ ,  $184^\circ\text{F}$ ); BP ( $125^\circ\text{C}$  at 25mmHg,  $347$ - $572^\circ\text{F}$  decomposes); SG (1.12); DN (1.122g/mL at  $30^\circ\text{C}$ ); VD (2.45); VP (0.007mmHg at  $20^\circ\text{C}$ , 1.6mmHg at  $84.5^\circ\text{C}$ ).

**CHEMICAL PROPERTIES:** readily polymerizes at the MP or under UV light; polymerization may be caused by oxidizers or peroxides; FP ( $137.8^\circ\text{C}$ ,  $280^\circ\text{F}$ ); LFL/UFL(NA); AT ( $240^\circ\text{C}$ ,  $464^\circ\text{F}$ );

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 2, Flammability 2, Reactivity 2; may polymerize violently upon melting; toxic oxides of nitrogen are produced during combustion; incompatible or reacts strongly with strong oxidizers; use alcohol foam, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (central nervous system, tremors, hallucinations, paralysis).

**FIRST AID:** wash eyes immediately with large amounts of water; flush the skin immediately with copious amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** EPA Cancer Risk Level (1 in a million excess lifetime risk)  $8.0 \times 10^{-7}$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; drowsiness; hallucinations; confusion; fatigue; central nervous system disturbances; incoordination; peripheral neuropathy.

**CHRONIC HEALTH RISKS:** damage to cardiovascular system; adverse blood effects; nerve damage; reddish rash; probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.03 mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.03 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.3 mg/m<sup>3</sup>; IDLH 60 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear positive pressure self-contained breathing apparatus; wear rubber gloves, boots, apron, etc.; wear chemical safety goggles.

**SPILL CLEAN-UP:** for small quantity, sweep onto paper, or other suitable material, place in appropriate container, and burn in safe place (such as fume hood); ventilate area; reclaim large quantities.

**DISPOSAL AND STORAGE METHODS:** package product residues in epoxy-lined drums and dispose of at an EPA-approved disposal site; destruction by high-temperature incineration with scrubbing equipment; deep well injection; store in a cool, dry, well-ventilated location; store away from heat, sunlight, acids, and alkalis; separate from oxidizing materials and peroxides.

**REGULATORY INFORMATION:** CA2; S1; S23; S32; S50-a; R4; R7; R8; U waste # (U007); Reportable Quantity (RQ): 5000 lbs (2270 kg); Sf1; Sf2; Sf3; T120-a; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used in the production of polyacrylamide polymers; absorbent in disposable diapers, medical products, agricultural products; sugar beet juice clarification; adhesives; textile printing paste.

**KEY REFERENCES:** 4; 5; 6; 10; 11; 12; 13.

## ACRYLONITRILE (C-3H3N, 53.07)

**CAS/DOT IDENTIFICATION #:** 107-13-1/UN1093

**SYNONYMS:** acrylon, cyanoethylene, 2-propenenitrile, vinyl cyanide

**PHYSICAL PROPERTIES:** colorless to pale yellow liquid; practically odorless, but can have a sweet, irritating odor; soluble in isopropyl alcohol, ether, acetone, benzene; miscible with ethanol, carbon tetrachloride, ethyl acetate, toluene, petroleum ether, and xylene; MP (-84°C, -118°F); BP (77°C, 171°F); SG (0.8004); DN (0.8004g/ml at 25°C); ST (27.3 dynes/cm at 24°C); VS (0.34 cP at 25°C); HV (265 Btu/lb, 147 cal/g, 6.16 x 10<sup>5</sup>J/kg); VD (1.83); VP (83mmHg at 20°C, 100mmHg at 23°C); OT (40.4 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** incompatible with oxidizers, acids, bases, bromine, amines; may polymerize due to exposure to light; attacks copper; FP (0°C, 32°F); LFL/UFL (3.0%, 7.0%); AT (481°C, 898°F); HC (-14,300 Btu/lb, -7930 cal/g); HF (147.1 kJ/mol liquid at 298.15K).

**EXPLOSION and FIRE CONCERNS:** dangerous fire hazard; NFPA rating Health 4, Flammability 3, Reactivity 2; may polymerize explosively on storage with silver nitrate; reacts violently with strong acids, strong bases, dibenzoyl peroxide, or bromine; incompatible or reacts strongly with strong oxidizers and amines; when heated to decomposition may evolve toxic hydrogen cyanide gas and oxides of nitrogen; use water, dry chemical, "alcohol-resistant" foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (headache, sneezing, nausea, vomiting); ingestion (weak-ness, lightheadedness, abdominal pain).

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**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with large amounts of water; if swallowed, induce vomiting by administering strong solution of salt water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLO 16ppm/20M; inhalation-man LCLO 1g/m<sup>3</sup>/IH; eye, pul-human TCLO- 16ppm/20M; skin-human 500mg; skin-child LDLO 2015 mg/kg.

**ACUTE HEALTH RISKS:** irritation of skin, eyes and upper respiratory tract; spasm, inflammation, and edema of the larynx and bronchi; chemical pneumonitis; pulmonary edema; coughing; wheezing; laryngitis; shortness of breath; burning sensation; headache; nausea; vomiting.

**CHRONIC HEALTH RISKS:** increased salivation; flushing of the face; irritation of the eyes, nose; photophobia; deepened respiration; weakness; oppressive feeling in chest; mild jaundice accompanied by mild anemia; leucocytosis; increase in bile pigment, serum, and bile thiocyanates.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2ppm (skin); OSHA PEL TWA 2ppm; OSHA (ceiling level) 10ppm/15M; NIOSH REL TWA 1ppm; NIOSH (ceiling level) 10ppm/15M; IDLH 85ppm.

**PERSONAL PROTECTION:** wear positive pressure self-contained breathing apparatus; wear rubber safety shoes, rubber gloves and aprons; wear chemical safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; re-move solutions by vacuum cleaning to prevent an increase in airborne concentrations; releases may require isolation or evacuation; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** dispose of by controlled incineration; remove nitrogen oxides from the effluent gas by scrubbers or thermal devices; activated carbon treatment is recommended; outside storage is preferred; inside storage should be in a standard flammable liquids storage room or cabinet.

**REGULATORY INFORMATION:** CA2; S3; F1; R2-17; R3; R4; R7; R8; U waste # (U009); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf2; Sf3; CW1; CW2; CW3; CW4; CW5; A1; A4; CAL; DOT hazard class/division (3); labels (flammable liquid, poison).

**OTHER COMMENTS:** used in the manufacture of acrylic fibers, plastics, rubber elastomers, dyes, nylon, pharmaceuticals.

**KEY REFERENCES:** 2; 4; 5; 6; 10; 11; 12; 13.

### **ALDRIN (C<sub>12</sub>H<sub>8</sub>Cl<sub>6</sub>, 364.9)**

**CAS/DOT IDENTIFICATION #:** 309-00-2/UN2761

**SYNONYMS:** aldrex; aldrosol; 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-exo-1,4-endo-5,8-dimethano-naphthalene; octalene

**PHYSICAL PROPERTIES:** colorless to dark brown crystals; mild chemical odor; insoluble in water; slightly soluble in petroleum ether; soluble in most organic solvents; MP (104°C, 219°F); BP (219°C, 426°F decomposes at 760mmHg); SG (1.60); VP (7.5 x 10<sup>-5</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable in presence of organic and inorganic alkalis; stable to the action of hydrated metal chlorides; compatible with most fertilizers, herbicides, fungicides and insecticides; incompatible or reacts strongly with concentrated mineral acids, active metals, acid catalysts, acid oxidizing agents, phenols;; FP (NA); LFL/UFL (NA).

**EXPLOSION and FIRE CONCERNS:** nonflammable; when heated to decomposition, emits toxic fumes of hydrochloric acid and other chlorinated hydrocarbons; use dry chemical, foam or carbon dioxide for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); skin absorption (headache, dizziness, nausea, vomiting).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human TDL0 14mg/kg; cyt-human: lym 1900mg/L; cyt-human: leu 19,125 g/L.

**ACUTE HEALTH RISKS:** headache; dizziness; nausea; vomiting; blood in the urine; tremors; convulsions; hyperirritability; coma.

**CHRONIC HEALTH RISKS:** muscular twitching; redness of the skin and dermatitis; weight loss; convulsions.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.25mg/m<sup>3</sup>; OSHA PEL TWA 0.25mg/m<sup>3</sup>; NIOSH REL TWA 0.15mg/m<sup>3</sup>; IDLH 25mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode; wear chemical protective clothing, gloves, aprons, etc.; wear chemical safety goggles.

**SPILL CLEAN UP:** ventilate area of spill or leak; solid or liquid may be vacuumed up with a high-efficiency filtration system; absorb small quantities of liquids on paper towels and place in appropriate container; large quantities of liquids may be absorbed in vermiculite, dry sand, earth, or a similar material.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in an appropriate container; store in tightly closed containers in a well ventilated area.

**REGULATORY INFORMATION:** F4; R3; R4; R5; R7; R8; P waste # (P004); Reportable Quantity (RQ): 1lb (0.454 kg); Sf1; Sf2; Sf3; CW1; CW2; CW4; CW5; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** most uses of aldrin were suspended by the USEPA, effective October 18, 1974; the only uses allowed are direct soil application, seed treatment if labeled "not for food use," dipping of plant roots and tops, and subsurface termite control.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

**ALLYL ALCOHOL (C<sub>3</sub>H<sub>6</sub>O, 58.09)**

**CAS/DOT IDENTIFICATION #:** 107-18-6/UN1098

**SYNONYMS:** 2-propenol, 2-propen-1-ol, vinyl carbinol

**PHYSICAL PROPERTIES:** colorless liquid; pungent, mustard-like odor; floats and mixes with water; miscible with water, alcohol, chloroform, ether, petroleum ether; MP (-129°C, -200°F); BP (97°C, 207°F); DN(0.8520 g/mL at 20°C); LSG(0.85); ST(25.28 mN/m at 298.15K); VS(mPas at 298.15K); CP(138.9 J/mol-K, liquid at 298.15K); VD(2.00); VP (10 mmHg at 10.5°C, 17mmHg at 20°C).

**CHEMICAL PROPERTIES:** reacts vigorously with strong oxidizers, acids, carbon tetrachloride; polymerization may be caused by elevated temperatures, oxidizers, or peroxides; FP(22°C, 72°F); LFL/UFL(2.5%, 18.0%); AT(378°C, 713°F); HF(-171.8 kJ/mol, liquid at 298.15K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; dangerous fire and explosion hazard; NFPA rating Health 3, Flammability 3, Reactivity 0; reacts violently with sulfuric acid, carbon tetrachloride; incompatible with chlorosulfonic acid, nitric acid, sulfuric acid, sodium hydroxide; combustion may produce irritants and toxic gases; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (eye irritation, tissue damage); skin absorption (irritation of upper respiratory system and skin, many cause pulmonary edema).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man LCLO 1000ppm/1H; eye-human 25ppm.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory tract.

**CHRONIC HEALTH RISKS:** tissue damage; may cause pulmonary edema.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2ppm; ACIH STEL 4ppm (skin); OSHA PEL TWA 2ppm; OSHA STEL 4ppm(skin); IDLH 20ppm.

**PERSONAL PROTECTION:** wear positive pressure self-contained breathing apparatus; wear special protective clothing, i.e., boots, gloves aprons, etc.; wear splash-proof safety goggles.

**SPILL CLEAN UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; control runoff and isolate discharged material for proper disposal; eliminate all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in an appropriate container; separate from strong oxidizing materials; store in a cool, dry well-ventilated location.

**REGULATORY INFORMATION:** F1; R4; R6; R8; P waste # (P005); Reportable Quantity (RQ): 100lbs (45.4 kg); Sf1; Sf2; Sf3; CW1; CW2; A1; CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid).

**OTHER COMMENTS:** used in the manufacture of resins, plasticizers, war gas; intermediate for pharmaceuticals and other organic chemicals.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 13.

**ALLYL CHLORIDE (H<sub>2</sub>C=CHCH<sub>2</sub>Cl, 76.53)**

**CAS/DOT IDENTIFICATION #:** 107-0501/UN1100

**SYNONYMS:** 3-chloropropene, 1-chloro-2-propene, 3-chloropropylene, 2-propenyl chloride

**PHYSICAL PROPERTIES:** colorless, brown, yellow, or purple liquid; pungent, unpleasant odor; slightly soluble in water; miscible with alcohol, chloroform, ether and petroleum ether; MP (-136.4°C, -213.5°F); BP (44.6°C, 112.3°F); DN (0.938g/mL at 20°C); LSG(0.94); ST (23.14 dynes/cm); VS (0.314mPas at 298.15K); HV (29.04 kJ/mol at 318K); VD (2.66); VP (295mmHg at 20°C); OT (1.2ppm).

**CHEMICAL PROPERTIES:** generally stable; incompatible with strong oxidizers, amines, acids, iron and aluminum chlorides, magnesium, zinc; polymerization may occur upon heating or when in contact with acids or galvanized metals; FP (-32°C, -25°F); LFL/UFL (2.9%, 11.2%); AT (905°F);

**EXPLOSION and FIRE CONCERNS:** dangerous fire and explosion hazard; extremely flammable liquid; NFPA rating Health 3, Flammability 3, Reactivity 1; vigorous or explosive reaction above -70°C with alkyl aluminum chlorides and aromatic hydrocarbons; violently exothermic polymerization reaction with aluminum chloride, boron trifluoride, sulfuric acid; incompatible or reacts strongly with nitric acid, ethylene imine, ethylenediamine, chlorosulfonic acid, oleum, sodium hydroxide; combustion will produce carbon dioxide, carbon monoxide, and hydrogen chloride; use carbon dioxide, alcohol foam, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, unconsciousness, irritates eyes, nose and throat); skin absorption (local vasoconstriction, numbness); ingestion (burns, severe irritation of gastrointestinal tract).

**FIRST AID:** was eyes immediately with large amounts of water; was skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** nose-human 25ppm; eye-human 5-100ppm; inhalation-human LCLO 3000ppm.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory passages; local vasoconstriction; dizziness; headache; numbness; unconsciousness; death in high exposures.

**CHRONIC HEALTH RISKS:** liver and kidney damage; affects the central nervous system; motor and sensory neurotoxic damage; pulmonary edema; EPA Group C: possible human carcinogen (cancer causing agent).

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm; ACGIH STEL 2ppm; OSHA PELTWA 1ppm; OSHA STEL 2ppm; DFG MAK 1ppm(3mg/m<sup>3</sup>); NIOSH REL TWA 1ppm.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus; wear protective clothing; chemical safety goggles, or gas mask if necessary.

**SPILL CLEAN UP:** remove all ignition sources; evacuate and cover area with activated carbon to absorb as much as possible; empty and deposit in sealed containers.

**DISPOSAL AND STORAGE METHODS:** store in a cool, dry, well-ventilated location; isolate from acid catalysts; outside storage preferred; inside should be in a standard flammable liquids storage room or cabinet; dispose of as a hazardous waste but keep out of confined space such as a sewer in order to avoid explosions.

**REGULATORY INFORMATION:** CA2; R3; R5; Reportable Quantity (RQ): 1000 lbs (454 kg); Sf1; Sf3; CW1; CW2; A1; A5; CAL. DOT hazard class/division (3); labels (flammable liquid, poison).

**OTHER COMMENTS:** used in the manufacture of adhesives, varnish, plastics, perfumes, pharmaceuticals, insecticides; used in the synthesis of allyl alcohol, allyl amines, polyesters.

**KEY REFERENCES:** 4; 5; 6; 8; 10; 12; 13.

### **ALLYL GLYCIDYL ETHER (C<sub>6</sub>H<sub>10</sub>O<sub>2</sub>, 114.2)**

**CAS/DOT IDENTIFICATION #:** 106-92-3/UN2219

**SYNONYMS:** AGE, 1-allyloxy-2,3-epoxypropane, [(2-propenyloxy)methyl]oxirane

**PHYSICAL PROPERTIES:** colorless liquid; pleasant odor; slightly soluble in water; miscible with acetone, toluene, and octane; BP (153.9°C, 309°F); FRZP (forms glass at -100°C, -148°F); DN (0.9698g/mL at 20°C); LSG(0.97); ST (NA); VS (NA); HV (NA); VD (3.32 at 25°C); VP (2mmHg at 20°C, 4.7mmHg at 25°C, 21.59mmHg at 60°C).

**CHEMICAL PROPERTIES:** reacts vigorously with strong oxidizing agents; FP (57.2°C, 135°F); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** a flammable liquid when exposed to heat or flame; when heated to decomposition emits acrid smoke and irritating fumes; use carbon dioxide, dry chemical powder, or appropriate foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and nose); skin absorption (respiratory system, dermatitis, pulmonary edema); ingestion (oral and esophageal burns, dyspnea, dysphagia, shock).

**FIRST AID:** irrigate eyes with copious amounts of tepid water for at least 15 minutes; wash skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** NA.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory tract; pulmonary edema; conjunctivitis; coughing; bronchospasm; CNS depression; cyanosis; paralysis; tremor; seizures; rt. muscular relaxation; esophagus burns; burns to the oral pharynx; dysphagia; drooling; hemolytic anemia.

**CHRONIC HEALTH RISKS:** dermatitis with itching, swelling and blisters; skin sensitization; cross sensitization with other epoxy agents.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5ppm; ACGIH STEL 10ppm(skin); OSHA PEL TWA 5ppm; OSHA STEL 10ppm; NIOSH REL TWA 5ppm (22mg/m<sup>3</sup>); NIOSH STEL 10ppm (44mg/m<sup>3</sup>)(skin); IDLH 50ppm.

**PERSONAL PROTECTION:** in high vapor concentrations, wear self-contained breathing apparatus; wear protective clothing (gloves, boots, aprons, etc.); wear splash-proof safety goggles.

**SPILL CLEAN UP:** NA.

**DISPOSAL AND STORAGE METHODS:** NA.

**REGULATORY INFORMATION:** A1; CAL. DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a resin intermediate; used as a stabilizer of chlorinated compounds, vinyl resins, and rubber.

**KEY REFERENCES:** 4; 5; 6; 7; 10; 12; 15.

### **ALLYL PROPYL DISULFIDE(C6H12S2, 148.3)**

**CAS/DOT IDENTIFICATION #:** 2179-59-1/None

**SYNONYMS:** 4,5-dithia-1-octene, onion oil, 2-propenyl propyl di-sulfide, propyl allyl disulfide

**PHYSICAL PROPERTIES:** pale-yellow liquid; strong and irritating onion-like odor; insoluble in water; soluble in ether, carbon disulfide, and chloroform; MP (-15°C, 5°F); BP (78°-80°C, 172.9°-176°F); SG (1.05); DN (0.9289 g/ml at 15°C); LSG (0.93 at 15°C); VD (5.12); VP (NO DATA); however, this substance is known to be volatile).

**CHEMICAL PROPERTIES:** unstable when exposed to heat, sparks, and open flames; reacts vigorously with strong oxidizing agents; FP (NO DATA); LFL/UFL(NO DATA); AT (NO DATA);

**EXPLOSION and FIRE CONCERNS:** moderate fire hazard; combustible liquid; NFPA not rated; incompatible or reacts strongly with perchlorates, peroxides, permanganates, chlorates, nitrates, chlorine, bromine, and fluorine; poisonous gases, such as sulfur oxides, are produced in fire; use dry chemical, carbon dioxide, or foam extinguishers for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, respiratory system, lacrimation (discharge of tears)); skin contact (skin irritation may result).

**FIRST AID:** flush eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** (NO DATA AVAILABLE); However, administration to six normal volunteers after a 12-hr fast caused a significant fall in the blood glucose levels and a significant rise in the se-rum insulin levels during the subsequent 4hr; an average concentration of 3.4 ppm was found to cause irritation to the eyes, nose and throat.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, throat, and mucous membranes; skin irritation; tearing eyes; runny nose.

**CHRONIC HEALTH RISKS:** no signs or symptoms of chronic exposure to allyl propyl disulfide have been reported; according to the information presently available to the New Jersey Department of Health, allyl propyl disulfide has not been tested for its ability to cause cancer in animals and for its ability to affect reproduction.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2ppm (12 mg/m<sup>3</sup>); ACGIH STEL 3ppm (18 mg/m<sup>3</sup>); OSHA PEL TWA 2ppm (12 mg/m<sup>3</sup>); OSHA STEL 3ppm (18mg/m<sup>3</sup>); NIOSH REL TWA 2ppm (12 mg/m<sup>3</sup>); NIOSH STEL 3ppm (18 mg/m<sup>3</sup>).

**PERSONAL PROTECTION:** wear protective clothing (suits, gloves, footwear, head-gear, etc.); wear splash-proof safety goggles and face shield; an approved full facepiece respirator is needed in areas where exposure would be above the PEL.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb liquids in vermiculite, dry sand, or earth; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb with sand or other noncombustible absorbent material and place the material in a covered container; store in a cool, dry well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard; store separately from oxidizers, heat sparks, and open flame.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a food additive in baked goods, in meat, meat sauces, soups, in condiments, and in pickles; used as a synthetic flavor.

**KEY REFERENCES:** 4; 5; 6; 14; 15.

### **ALPHA-ALUMINA (Al<sub>2</sub>O<sub>3</sub>, 101.96)**

**CAS/DOT IDENTIFICATION #:** 1344-28-1/None

**SYNONYMS:** alumina, aluminum oxide, aluminum trioxide, aluminite

**PHYSICAL PROPERTIES:** white crystalline powder; odorless; very hard, about 8.8 on Moh's scale; practically insoluble in water, non-polar organic solvents; slowly soluble in aqueous alkaline solution, forming hydroxides; very slightly soluble in acid, alkali; soluble in cold water; insoluble in hot water; MP (2000°C, 3632°F); BP (2980°C, 5396°F); SG (4.0); DN (4.0 g/ml at 20°C); ST (NO DATA); VS (NO DATA); Cp<sub>mean</sub> (795.6J/kg-K); HV (NO DATA); VD (NO DATA); VP (1 mmHg at 2158°C).

**CHEMICAL PROPERTIES:** noncombustible solid; reacts vigorously with chlorine trifluoride, hot chlorinated rubber, acids, and oxidizers; exothermic reaction above 200°C with halocarbon vapors produces toxic hydrogen chloride and phosgene; FP (NO DATA); LFL/UFL(NO DATA); AT (NO DATA); HC (NO DATA); HF (111.1 kJ/mol at 2327K).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid, but dusts may form explosive mixtures in air; NFPA (not rated); not compatible with hot chlorinated rubber; hydrogen gas may be formed when finely divided iron contacts moisture during crushing and milling operations; use dry chemical, carbon dioxide, or foam extinguishers for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory system); skin contact (delayed hypersensitivity, granulomas).

**FIRST AID:** wash eyes immediately with large amounts of water; gently blot skin or brush away excess and then wash contaminated skin with water; provide respiratory support.

**HUMAN TOXICITY DATA:** (NO DATA AVAILABLE); oral toxic doses in man are not well established; oral animal LD<sub>50</sub>'s are 1 to 4 g/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and throat; severe bone pain, fractures and crippling deformities; visual and auditory hallucinations.

**CHRONIC HEALTH RISKS:** asthma; chronic obstructive lung disease; pulmonary fibrosis; chronic interstitial pneumonia; dyspnea; coughing; shortness of breath; renal failure; seizures; coma; death.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup> of total dust (when toxic impurities are not present); OSHA PEL TWA 15 mg/m<sup>3</sup> of total dust; OSHA PEL TWA 5mg/m<sup>3</sup> of respirable fraction.

**PERSONAL PROTECTION:** wear protective clothing (suits, gloves, footwear, headgear, etc.); wear dust-proof goggles when working with powders or dust; appropriate respirators are needed in areas where exposure would be above 10mg/m<sup>3</sup>.

**SPILL CLEAN-UP:** collect powdered material and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; do not dry sweep.

**DISPOSAL AND STORAGE METHODS:** store in tightly closed containers in a cool, well-ventilated area; contain and dispose of aluminum oxide as a hazardous waste; contact the Department of Environmental Protection (DEP) or the federal Environmental Protection Agency (EPA) for specific recommendations.

**REGULATORY INFORMATION:** CAL.

**OTHER COMMENTS:** used as an adsorbent, in abrasive and aluminum manufacturing, in paper, spark plugs, fluxes and heat resistant fibers, and in chromatographic analysis.

**KEY REFERENCES:** 3; 4; 6; 9; 15.

## ALUMINUM (Al, 27.0)

**CAS/DOT IDENTIFICATION #:** 7429-90-5/UN1309/UN1396

**SYNONYMS:** aluminum metal (OSHA); aluminum powder, coated (UN1309)(DOT); aluminum powder, uncoated (UN1396)(DOT); elemental aluminum

**PHYSICAL PROPERTIES:** gray to silver powdered metal; metallic odor when dust is inhaled; soluble in HCL, H<sub>2</sub>SO<sub>4</sub>, alkalis; insoluble in concentrated nitric acid, hot acetic acid; insoluble in cold and hot water; MP (660°C, 1221°F); BP (2467°C, 4473°F); DN (2.702g/mL); SG(2.70); ST (NA); VS (NA); HV (NA); VD (NA); VP (1mmHg at 1284°C).

**CHEMICAL PROPERTIES:** combustible solid; finely divided dust is easily ignited; reacts with oxidizing materials, acid chlorides, metal salts, other materials; reacts with strong acids, strong alkalis to release hydrogen gas; FP (NA); LFL/UFL (NA); AT (760°C, 1400°F); HC (NA).

**EXPLOSION and FIRE CONCERNS:** flammable solid if finely divided; NFPA rating Health 0, Flammability 3, Reactivity 1; forms explo-sive mixtures in a dust cloud in air; bulk dust when damp with water may heat spontaneously; hazard greater as fineness increases; forms sensitive explosive mixtures with oxidants such as liquid Cl<sub>2</sub> and other halogens, tetranitromethane, bromates, iodates, NaClO<sub>3</sub>, KClO<sub>3</sub>, and other chlorates, aqueous nitrates, sodium peroxide, zinc peroxide, and powdered polytetrafluoroethylene (PTFE); smother with dry sand, dry clay, dry ground limestone, or use approved Class D extinguishers for firefighting purposes; do not use carbon dioxide or halogenated extinguishing agents; do not use water.

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**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, respiratory system, and pulmonary fibrosis); skin absorption (inflammation or corrosion of the skin and mucous membranes); ingestion (gastrointestinal irritation, nausea, vomiting, abdominal pain, diarrhea).

**FIRST AID:** flush eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** NA.

**ACUTE HEALTH RISKS:** irritates skin, eyes, respiratory system; fever; chills; aches; chest tightness; coughing; metallic taste.

**CHRONIC HEALTH RISKS:** pulmonary fibrosis (scarring of the lungs); chronic obstructive lung disease; asthma; coughing; shortness of breath.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10mg/m<sup>3</sup>(dust); OSHA PEL TWA 15 mg/m<sup>3</sup>(total dust); OSHA PEL TWA 5mg/m<sup>3</sup> (respirable fraction); NIOSH REL TWA 10mg/m<sup>3</sup> (total dust); NIOSH REL TWA 5mg/m<sup>3</sup>;(respirable fraction).

**PERSONAL PROTECTION:** wear full protective clothing (suits, gloves, footwear, headgear, etc.); wear positive pressure self-contained breathing apparatus; wear dust-proof goggles and face shield.

**SPILL CLEAN UP:** shovel into suitable dry container; remove all ignition sources; do not use water to clean spilled aluminum powder.

**DISPOSAL AND STORAGE METHODS:** collect powdered material and deposit in sealed containers; store in tightly closed containers in a cool, well-ventilated area away from water and moisture; separate from acids, alkalies, halogenated compounds, oxidizers, combustible materials; use explosion-proof electrical equipment and fittings.

**REGULATORY INFORMATION:** Sf3; CAL; DOT hazard class/division (4.1); labels (flammable solid) UN1309; DOT hazard class/division(4.3); labels (dangerous when wet) UN1396.

**OTHER COMMENTS:** used as a powder in paints and protective coatings, as rocket fuel, as a catalyst, and for foamed concrete vacuum metallizing and coating.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 15.

### 4-AMINODIPHENYL (C<sub>6</sub>H<sub>5</sub>C<sub>6</sub>H<sub>4</sub>NH<sub>2</sub>,169.2)

**CAS/DOT IDENTIFICATION #:** 92-67-1/None

**SYNONYMS:** 4-aminobiphenyl, p-aminobiphenyl, p-aminodiphenyl, 4-phenylaniline

**PHYSICAL PROPERTIES:** leaflets or colorless crystals; floral odor; slightly soluble in cold water; soluble in hot water, alcohol, chloroform; MP (52°-54°C, 125.6°-129.2°F); BP (302.2°C, 576°F at 760mmHg, 191°C, 375.8°F at 15mmHg); DN (1.160 g/ml at 20°C); LSG (1.16); VP (1mmHg at 68°F).

**CHEMICAL PROPERTIES:** combustible solid, but must be pre-heated before ignition possible; oxidized by air; incompatible with acids, acid anhydrides and oxidizing agents; LFL/UFL(not determined); AT (450°C, 842°F).

**EXPLOSION and FIRE CONCERNS:** slight to moderate fire hazard when exposed to heat, flames (sparks), or powerful oxidizers; when heated to decomposition it emits toxic fumes of NO<sub>x</sub>; use water spray, mist, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, lethargy, dyspnea); skin absorption (ataxia, coma seizure, weakness); ingestion (urinary burning, acute hemorrhagic cystitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** msc-hmn: fbr 60mg/L; target organs bladder, skin.

**ACUTE HEALTH RISKS:** irritation of skin and yes; irritating to mucous membrane and upper respiratory tract; absorption into body may cause cyanosis.

**CHRONIC HEALTH RISKS:** may alter genetic material; highly toxic suspected human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA confirmed human carcinogen; OSHA PEL cancer suspect agent; NIOSH REL carcinogen; IDLH carcinogen, no level detected.

**PERSONAL PROTECTION:** wear full protective clothing; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** cover spill with dry lime or soda ash; keep in closed container and dispose of properly; ventilate area and wash spill site after complete material pickup.

**DISPOSAL AND STORAGE METHODS:** store in a cool, well ventilated area; store separately from strong oxidizers, heat and flame; absorb as much as possible with sand or other noncombustible absorbent material and place in a sanitary landfill.

**REGULATORY INFORMATION:** CA2; R3; R4; R5; Reportable Quantity (RQ): 11b (0.454kg); Sf3; A1; A4; CAL.

**OTHER COMMENTS:** used in organic research; used as a carcinogen in cancer research; also used as a dye intermediate.

**KEY REFERENCES:** 4; 5; 6; 7; 12; 13; 14.

## **2-AMINOPYRIDINE (NH<sub>2</sub>C<sub>5</sub>H<sub>4</sub>N, 94.13)**

**CAS/DOT IDENTIFICATION #:** 504-29-0/UN2671

**SYNONYMS:** o-aminopyridine, alpha-aminopyridine, amino-2-pyridine, alpha-pyridinamine, alpha-pyridylamine, 2-pyridylamine.

**PHYSICAL PROPERTIES:** white powder, leaflets, or large color-less crystals; characteristic odor; soluble in water, alcohol, benzene, ether, and hot petroleum ether; slightly soluble in ligroin; MP (58°C, 136°F); BP (211°C, 412°F); DN (unknown); SG (unknown); VD (3.2); VP (0.8 mmHg at 77°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; substance is a strong base that is soluble in water; reacts with strong oxidants; FP (68°C, 154°F); LFL/UFL (unknown); AT (unknown).

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**EXPLOSION and FIRE CONCERNS:** combustible solid; vapors can form explosive mixtures with air at elevated temperatures; dust explosion possible if in powder or granular form and mixed with air; reacts with strong oxidizers causing fire and explosion hazard; decomposes on burning producing highly toxic fumes of oxides of nitrogen; use powder, alcohol-resistant foam, water spray or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sommolence, convulsions, anti-psychotic effects, respiratory failure, dizziness, headache, shortness of breath, nausea, increased blood pressure, collapse); skin/eye contact (redness); skin absorption (excitement, stupor, weakness); ingestion (symptoms parallel those of inhalation).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if swallowed, rinse mouth and get medical attention immediately.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 5 ppm/5H; toxic effect: central nervous system.

**ACUTE HEALTH RISKS:** headache; dizziness; nausea; weakness; irritation of eyes, nose and throat; shortness of breath; respiratory distress; respiratory failure; high blood pressure; excitement; stupor; convulsions; collapse; may result in death.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (1.9 mg/m<sup>3</sup>); OSHA PEL TWA 0.5 ppm (2mg/m<sup>3</sup>); NIOSH REL TWA 0.5 ppm (2 mg/m<sup>3</sup>); IDLH 5 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use eye protection in combination of breathing protection; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use dust explosion-proof electrical equipment and lighting; use self-contained breathing apparatus in oxygen deficient atmospheres; for extra personal protection, a P3 filter respirator for toxic particles is recommended.

**SPILL CLEAN-UP:** ventilate area of leak or spill; sweep spilled sub-stance into sealable containers; moisten first to prevent dusting; carefully collect remaining material and remove to a safe place; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an approved waste disposal facility; dispose of container and unused contents in accordance with local, state, and federal regulations; store in a cool, dry location; maintain adequate ventilation; separate from strong oxidants, food, and feedstuffs.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as an intermediate in the manufacture of antihistamines and other pharmaceuticals; useful in the manufacture of dyes.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

**AMMONIA (H<sub>3</sub>N, 17.04)**

**CAS/DOT IDENTIFICATION #:** 7664-41-7/UN1005

**SYNONYMS:** anhydrous ammonia, aqua ammonia, aqueous ammonia

**PHYSICAL PROPERTIES:** colorless, alkaline gas; pungent, suffocating odor; easily liquefied under pressure; liquid released under pressure floats and boils on water; forms aqueous solutions with high vapor pressure; very soluble in water; moderately soluble in alcohol; MP (-78°C, -108°F); BP (-33°C, 28°F); DN (0.6818g/mL at -33.35°C, 1 atm, 0.6585g/mL at -15°C, 2.332 atm); LSG(0.68 at -33°C); ST (23.4 dynes/cm at 11.1°C, 18.1 dynes/cm at 34.1°C); VS (0.475, 0.317, 0.276, 0.255 cP at -69, -50, -40, -33.5°C, respectively); HV (5.581 kcal/mol); VD (0.59 at 32°F); VP (400mmHg liquid at -45.4°C); OT (LT 0.0266 mg/m<sup>3</sup>, HT 39.6000mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** reacts vigorously with strong oxidizers, acids, halogens, salts of silver and zinc; corrosive to copper and galvanized surfaces; FP (NA, gas); LFL/UFL (16%, 25%); AT (651°C, 1204°F); HC ( -7920Btu/lb, -4440cal/g, -185.9 x 105 J/kg).

**EXPLOSION and FIRE CONCERNS:** explosion hazard when ex-posed to flame; NFPA rating Health 3, Flammability 1, Reactivity 0; ammonia + air in a fire can detonate; forms sensitive explosive mixtures with hypochlorite or other halogen sources; incompatible in contact with Ag, acetaldehyde, halogens, chlorites, and salts of silver and zinc; emits toxic fumes of ammonia and NO<sub>x</sub> when exposed to heat; use dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation(irritates eyes, nose and throat, violent coughing, severe lung irritation, pulmonary edema); skin absorption (skin burns, vesiculation, frostbite(liq)).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with water; if swallowed, drink water or milk; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCL0 30,000ppm/5M; inhalation-humanTCL0 20ppm;IRR; unk-man LDLO 132mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, throat; inflammation or edema of the larynx; laryngeal spasm; dyspnea; bronchospasm; frostbite; death in high exposures.

**CHRONIC HEALTH RISKS:** chest pain; pulmonary edema; pink frothy sputum; vesiculation.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25ppm; ACGIH STEL 35ppm; OSHA PEL TWA 50ppm (35 mg/m<sup>3</sup>); NIOSH REL TWA 25ppm(18mg/m<sup>3</sup>); NIOSH STEL 35ppm (27mg/m<sup>3</sup>); IDLH 300ppm.

**PERSONAL PROTECTION:** wear rubber overclothing, including gloves, boots, sleeves, aprons, etc.; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN UP:** ventilate area of spill or leak to disperse gas; use water spray to cool, absorb, and disperse vapors; if in liquid form, allow to vaporize.

**DISPOSAL AND STORAGE METHODS:** absorb it in dry earth or sand and place in a sanitary landfill; pour into large tank of water, neutralize, and route to sewage plant; store in a cool, dry, well ventilated location; separate from oxidizing materials, acids, and halogens.

**REGULATORY INFORMATION:** F2, Sf1; Sf2; CW1; CW2; A1; A5; CAL; Reportable Quantity (RQ): 100lbs(45.4kg); DOT hazard class/division (2.2); labels (non-flammable gas).

**OTHER COMMENTS:** used in the manufacture of nitric acid, explosives; in refrigeration, and chemical industry; used in the manufacture of pesticides and detergents; used in metal-treating operations such as annealing, furnace brazing, sintering.

**KEY REFERENCES:** 1; 3; 4; 5; 6; 10; 11; 12.

**AMMONIUM SULFAMATE (NH<sub>4</sub>OS<sub>2</sub>NH<sub>2</sub>,114.1)**

**CAS/DOT IDENTIFICATION #:** 7773-06-0/UN1651

**SYNONYMS:** ammate herbicide, ammonium amidosulfonate; AMS, monoammonium salt of sulfamic acid, sulfamate.

**PHYSICAL PROPERTIES:** colorless to white crystalline (sand-like) solid; odorless solid; soluble in water; slightly soluble in ethanol; moderately soluble in glycerol, glycol, liquid ammonia, and formamide; MP (131°C, 268°F); BP (160°C, 320°F); DN (more than 1 at 20°C, solid); SG (1.77); VP (0mmHg at 20°C).

**CHEMICAL PROPERTIES:** noncombustible solid; reacts vigorously with acids and hot water; hydrolyzes in hot acid solution; elevated temperatures cause a highly exothermic reaction with water; dehydrates liquid or solid amides to nitriles; liberates ammonia at elevated temperatures and forms imidodisulfonates; forms addition products with formaldehyde and aldehydes; readily oxidized by bromine and chlorine; has flame retardant properties because heat decomposition produces non-inflammable gases; decomposes at 200°C (392°F) at 760 mmHg; FP (N/A); LFL/UFL(N/A); AT (N/A).

**EXPLOSION and FIRE CONCERNS:** not flammable; NFPA not rated; somewhat explosive when heated or by spontaneous chemical reaction in a hot acid solution; contact with strong oxidizers may cause fires and explosions; contact with hot water may cause formation or large amounts of steam; when heated to decomposition, emits very toxic fumes of ammonia, nitrogen oxides and sulfur oxides; use dry chemical, carbon dioxide, water spray or regular foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, nose and throat); skin absorption (coughing, difficult breathing, nausea, vomiting).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** no data available; however, repeated application of a 4% solution to the anterior surface of one arm of each of five human subjects for five days caused no skin irritation.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, throat; coughing; dyspnea (shortness of breath).

**CHRONIC HEALTH RISKS:** cancer hazard; reproductive effects; has not been tested for other chronic (long-term) health effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10mg/m<sup>3</sup>; OSHA PEL TWA 15mg/m<sup>3</sup> (total particulate), 5mg/m<sup>3</sup> (respirable fraction); NIOSH REL TWA 10mg/m<sup>3</sup> (total particulate), 5mg/m<sup>3</sup> (respirable fraction); IDLH 1500mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear protective clothing (suits, gloves, footwear, headgear, etc.); wear dust-proof goggles and face shield when working with powders or dust; if exposure above 5000mg/m<sup>3</sup> exists, use an approved self-contained breathing apparatus.

**SPILL CLEAN-UP:** with clean shovel place material into clean, dry container and cover loosely; absorb as much as possible with sand or other noncombustible absorbent material; cover

powder spill with plastic sheet or tarp to minimize spreading but prevent entry into waterways, sewers, basements or confined areas.

**DISPOSAL AND STORAGE METHODS:** store in tightly closed containers in a cool, well-ventilated area; store separately from strong oxidizers (such as perchlorates, peroxides, permanganates, chlorates, nitrates, chlorine, bromine and fluorine), strong acids (such as hydrochloric, sulfuric and nitric) and hot water; absorb it in dry earth or sand and place in a sanitary landfill; consult with environmental regulatory agencies for guidance on acceptable disposal practices.

**REGULATORY INFORMATION:** F2; Sfl, CW1; CW2; A1; CAL; Reportable Quantity (RQ): 5000lbs (2270kg).

**OTHER COMMENTS:** used in the manufacture of fire retardant compositions for flame-proofing textiles and paper products; used in flameproofing wood; used to treat cigarette paper so as to reduce the hazard of tumor formation from tobacco smoke; used as soil treatment/for weed control/on apples, pears, fruit trees and ornamental trees.

**KEY REFERENCES:** 4; 5; 6; 12; 14; 15.

### **N-AMYL ACETATE (CH<sub>3</sub>COO[CH<sub>2</sub>]<sub>4</sub>CH<sub>3</sub>, 130.2)**

**CAS/DOT IDENTIFICATION #:** 628-63-7/UN1104

**SYNONYMS:** amyl acetic ester, amyl acetic ether, 1-pentanol acetate, pentyl ester of acetic acid, primary amyl acetate.

**PHYSICAL PROPERTIES:** colorless liquid; pear or banana-like odor; very slightly soluble in water; soluble in all proportions in alcohol and ether; soluble in acid; MP (-70.8°C, -95.0°F); BP (149°C, 300°F at 760 mmHg); DN (0.8756 g/mL at 20°C); LSG (0.88); ST (12 dynes/cm, 0.012 N/m at 30°C); VS (1.58 cP at 11°C); HV (140 Btu/lb, 75 cal/g); VD(4.5); VP (5mmHg at 25°C); OT (0.15 ppm).

**CHEMICAL PROPERTIES:** unstable when exposed to heat, sparks, or flames; may polymerize when heated; reacts vigorously with strong oxidizers, strong alkalis, acids and nitrates; FP (25°C, 77°F); LFL/UFL(1.1%, 7.5%); AT (360°C, 680°F); HC (1042.5 kcal/gmol wt at 20°C);

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; dangerous fire risk; NFPA rating Health 1, Flammability 3, Reactivity 0; poisonous gases are produced in fire; moderately explosive in the form of vapor when exposed to flame; vapor is heavier than air and may travel a distance to cause a fire or explosion far from the source; toxic gases (such as carbon monoxide), acrid smoke, and irritating fumes may be released when heated to decomposition; incompatible or reacts on contact with nitrates, strong oxidizers, strong alkalis, or strong acids; use dry chemical, carbon dioxide or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, nose, throat); skin absorption (giddiness, headache, nausea, delirium).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 5000mg/m<sup>3</sup>/30M; toxic effects: central nervous system, pulmonary system; inhalation-human TCLo 200ppm; toxic effects: central nervous sys-tem; eye-human 300ppm.

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**ACUTE HEALTH RISKS:** irritation of eyes, nose, throat; headache; dizziness; cardiac arrhythmia; narcosis; nausea; pulmonary edema; weakness; skin irritation.

**CHRONIC HEALTH RISKS:** liver damage; defatting of skin; contact dermatitis; reduced memory and concentration; personality changes (withdrawal, irritability); fatigue; sleep disturbances; reduced coordination; effects on nerves supplying internal organs; effects on nerves to the arms and legs (weakness, "pins and needles").

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; OSHA PEL TWA 100 ppm (525 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (525 mg/m<sup>3</sup>); IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear solvent-resistant gloves and clothing; wear splash-proof chemical safety goggles; in high vapor concentrations, wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb liquids in vermiculite, dry sand, earth, or other noncombustible material; flush remaining n-amyl acetate with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove any hot metal surface and all sources of heat and ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; large quantities can be atomized in a suitable combustion chamber; store in a cool, dry, well-ventilated area; large quantities should be stored outdoors, in above ground storage tanks; store separately from strong oxidizers (such as nitrates, permanganates, chlorine, chlorine dioxide and bromine); strong alkalis (such as sodium hydroxide and potassium hydroxide); and strong acids (such as hydrochloric and nitric).

**REGULATORY INFORMATION:** T30-e10, T120-d10; T799-5000; Reportable Quantity (RQ): 5000lbs (2270kg); DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent of lacquers and paints; used to extract penicillin from fermentation broth during production of antibiotics; used in the manufacture of photographic film; used in pre-spotting and spotting operations in the dry cleaning industry.

**KEY REFERENCES:** 4; 5; 6; 8; 12; 14; 15; 16.

### **SEC-AMYL ACETATE (CH<sub>3</sub>COO[CH<sub>3</sub>]C<sub>3</sub>H<sub>7</sub>,130.2)**

**CAS/DOT IDENTIFICATION #:** 626-38-0/UN1104

**SYNONYMS:** 1-methylbutyl acetate, 2-pentanol acetate, 2-pentyl ester of acetic acid.

**PHYSICAL PROPERTIES:** clear, colorless liquid; mild, transient, fruity odor; slightly soluble in water; soluble in alcohol and ether; MP (-78°C, -109°F); BP (121°C, 249°F); DN (0.862-0.866 g/mL at 20°C); LSG (0.87); VS (75 cP); VD(4.5); VP (7mmHg at 20°C); OT (0.002-0.08 ppm).

**CHEMICAL PROPERTIES:** heat contributes to instability; reacts vigorously with strong oxidizers, strong alkalis, strong acids and nitrates; may soften or dissolve plastics; FP (32°C, 89°F); LFL/UFL(1.0%, 7.5%); AT (NO DATA); HC (-14.402 Btu/lb, -8000 cal/g).

**EXPLOSION and FIRE CONCERNS:** dangerous fire hazard; NFPA rating Health 1, Flammability 3, Reactivity 0, contact with nitrates, strong oxidizers, alkalis, and acids may cause fires; moderately explosive in the form of vapor; vapors may travel to a source of ignition and flashback; vapor explosion hazard indoors, outdoors, or in sewers; poisonous gases are pro-

duced in fire; toxic gases (such as carbon monoxide) may be re-released when sec-amyl acetate is heated to decomposition; use dry chemical, carbon dioxide, or alcohol foam for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat, dizziness, drowsiness, headache); skin absorption (redness, pain); ingestion (abdominal pain, nausea).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TLo 200ppm; toxic effects: sense organs and special senses (nose, eye, ear, and taste); lung, thorax, or respiration.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; dizziness; drowsiness; headache; sore throat; abdominal pain; nausea.

**CHRONIC HEALTH RISKS:** defatting of the skin; dermatitis; possible kidney, liver injury; possible central nervous system depression.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 125 ppm; OSHA PEL TWA 125 ppm (650 mg/m<sup>3</sup>); NIOSH REL TWA 125 ppm (650 mg/m<sup>3</sup>); IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear chemical protective clothing (suits, gloves, footwear, headgear, etc.), constructed of polyvinyl alcohol material; wear splash-proof chemical safety goggles; appropriate respirators are needed in areas where exposure would be above the PEL (125ppm); in high vapor concentrations, wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with sand or other noncombustible absorbent material; flush remaining sec-amyl acetate with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent and place in a sanitary landfill; atomize large quantities in a sanitary landfill; atomize large quantities in a suitable combustion chamber; store in a cool, well-ventilated area away from heat; store separately from strong oxidizers (such as sodium hydroxide and potassium hydroxide), and strong acids (such as nitric, hydrochloric, and sulfuric); store in detached warehouse under full fire prevention control.

**REGULATORY INFORMATION:** Sfl; A1; CAL; Reportable Quantity (RQ): 5000lbs (2270kg); DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for metallic paints fine per-fumes, nail enamels, cements, coated paper, lacquers, leather finishes, linoleum, plastic wood, textile sizing, printing compounds, and washable wallpaper.

**KEY REFERENCES:** 3; 4; 5; 6; 8; 9; 11; 12; 14; 15; 16.

## **ANILINE AND HOMOLOGS (C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub>,93.14)**

**CAS/DOT IDENTIFICATION #:** 62-53-3/UN1547

**SYNONYMS:** aminobenzene, aniline oil, benzenamine, phenylamine

**PHYSICAL PROPERTIES:** colorless, oily liquid; aromatic amine-like odor; burning taste; soluble in water, alcohol, ether, and benzene; miscible with chloroform, carbon tetrachloride.

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ride and acetone; miscible with lip-ids, vegetable oils and essential oils; MP (-6.3°C, 20.7°F); BP (184°C, 363°F); DN (1.022 g/mL at 20°C); SG (1.0216); ST (44.1 dynes/cm at 10°C in contact with air); VS (4.423-4.435 cP at 20°C); VP (0.67mmHg at 25°C); OT (0.5 ppm).

**CHEMICAL PROPERTIES:** stable but combustible; polymerizes to a resinous mass; volatile with steam; reacts vigorously with strong oxidizers, strong acids, toluene diisocyanate and alkalis; FP (158°F); LFL/UFL(1.3%, 11%); AT (615°C, 1139°F); HC (-14.980 Btu/lb, -348.3 x 105 J/kg, -8320 cal/g).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 3, Flammability 2, Reactivity 0; spontaneous explosive reactions with dibenzol peroxide, fluorine nitrate, nitrosal perchlorate, red fuming nitric acid, and tetranitromethane; reacts violently with boron chloride, peroxyformic acid, fluorine, trichloronitromethane, acetic anhydride, chlorosulfonic acid, perchromates, oleum and n-halomides; ignites on contact with sodium peroxide and water; forms heat-or shock-sensitive explosive mixtures with hydrogen peroxide, nitromethane and 1-chloro-2,3-epoxypropane; reactions with ozone and perchloric acid form explosive products; decomposition emits highly toxic fumes of NOx; use alcohol foam, dry chemical, water spray, or carbon dioxide for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of respiratory tract, blue discoloration of fingertips, cheeks, nose, and lips, nausea, vomiting, headache, drowsiness, delirium, coma, shock); skin absorption (ataxia, dyspnea); ingestion (tachycardia, irritation of digestive tract).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** unknown-human LDLo 357mg/kg; unknown-man LDLo 150mg/kg.

**ACUTE HEALTH RISKS:** irritation of skin, eyes and upper respiratory tract; drowsiness; headaches; dizziness; weakness; blue discoloration of fingertips, lips and nose; nausea; vomiting; convulsions; delirium; coma; shock; tachycardia; hemolysis of the red blood cells; liver damage.

**CHRONIC HEALTH RISKS:** decrease in red blood cell count and hemoglobin levels; malignant bladder growths; irritation to mucous membranes; cyanosis; insomnia; headache; dizziness; loss of appetite; loss of weight; visual disturbances; skin lesions.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm; ACGIH STEL 20mg/m<sup>3</sup>; OSHA PEL TWA 5 ppm (19 mg/m<sup>3</sup>); DFG MAK 2ppm (8mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear protective clothing, rubber gloves, rubber shoes, aprons, etc.; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb spilled aniline in vermiculite, dry sand, or earth, and properly dispose.

**DISPOSAL AND STORAGE METHODS:** store in cool, dry, well-ventilated location away from sources of ignition and contact with oxidizing materials; absorb onto thick layer of sand-soda ash mixture and place in a sanitary landfill; dissolve in flammable solvent and burn in incinerator with afterburner and scrubber.

**REGULATORY INFORMATION:** CA2; R4; R5; R7; R8; U waste # (U012); Reportable Quantity (RQ): 5000 lbs (2270kg); Sf1, Sf2, Sf3; CW1, CW2, T799-18; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of resins, varnishes, paint removers, perfumes, and printing inks; used as a chemical intermediate in the production of pharmaceuticals, artificial sweeteners, dyes and pigments.

**KEY REFERENCES:** 3; 4; 5; 6; 8; 10; 11; 12; 15.

**ANISIDINE: o-, p-isomers (NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>OCH<sub>3</sub>, 123.2)**

**CAS/DOT IDENTIFICATION #:** 29191-52-4/UN2431

**SYNONYMS:** (o-Anisidine): ortho-aminoanisole; 2-anisidine; o-methoxyaniline; (p-Anisidine): para-aminoanisole; 4-anisidine; p-methoxyaniline.

**PHYSICAL PROPERTIES:** (o-Anisidine): red or yellow, oily liquid; amine-like odor; insoluble in water; soluble in dilute mineral acids, alcohol and ether; MP (57.2°C, 135°F); BP (225°C, 437°F); DN (1.097 g/mL at 20°C); SG (1.10); VP (<0.1 mmHg at 20°C); (p-Anisidine): yellow to brown, crystalline solid; amine-like odor; sparingly soluble in water; very soluble in methanol and ethanol; MP (57.2°C, 135°F); BP (246°C, 475°F); DN (1.089 g/mL at 55°C); SG (1.07); VP (0.006 mmHg at 77°F).

**CHEMICAL PROPERTIES:** both isomers are generally stable; may polymerize when heated; o- and p-anisidine react vigorously with strong oxidizers; liquid anisidine may break down some types of plastics, coatings, and rubber; o- and p- anisidine may covalently bond with any humic matter present in both soil and water; both isomers are volatile with steam; (o-Anisidine): FP (244°F); (p-Anisidine): FP (unknown); flammability limits not available.

**EXPLOSION and FIRE CONCERNS:** combustible material; may burn but does not ignite readily; NFPA rating Health 2, Flammability 1, Reactivity 0; explosion may result if o- or p- anisidine comes into contact with strong oxidizers; toxic vapors of NO<sub>x</sub> are emitted when o- or p-anisidine are heated to decomposition; when anisidine decomposes, poisonous gases, such as carbon monoxide, may be emitted; use dry chemical, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headaches, dizziness, cyanosis); skin absorption (RBC Heinz bodies); ingestion (esophageal or gastrointestinal tract irritation).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** the minimum lethal human exposure to this agent has not been delineated; however, workers exposed for 6 months to 0.4 ppm of anisidines in air for 3.5 hours each day experienced headaches and vertigo, increased sulfhemoglobin and methemoglobin levels, and continual occurrence of erythrocytic inclusion bodies.

**ACUTE HEALTH RISKS:** eye and skin irritation; irritation to mucous membranes and upper respiratory tract; cyanosis; headaches; dizziness.

**CHRONIC HEALTH RISKS:** allergic respiratory and skin reactions; anemia; increased sulfhemoglobin and methemoglobin levels; RBC Heinz bodies (carcinogen).

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>; OSHA PEL TWA 0.5 mg/m<sup>3</sup>; NIOSH REL TWA 0.5mg/m<sup>3</sup>; IDLH 50mg/m<sup>3</sup>.

## 412 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**PERSONAL PROTECTION:** wear chemical protective clothing which is specifically recommended by the manufacturer; wear dust- and splash-resistant safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb or cover with dry earth, sand or other non - combustible material; prevent entry into waterways, sewers, basements or confined areas; remove all ignition sources (no smoking, flares, sparks or flames in immediate area).

**DISPOSAL AND STORAGE METHODS:** absorb liquids containing anisidine in vermiculite, dry sand or earth, and place in a sanitary land-fill; cover o-anisidine with a combination of 9 parts sand to 1 part soda ash; mix and transfer all material in a paper carton; burn the carton in an open furnace with a scrubber and afterburner; o-anisidine may be dissolved in a flammable solvent (e.g. alcohol) and atomized in a suitable combustion chamber; store both isomers in a cool, dry location; keep o-anisidine and p-anisidine away from heat and open flame; for p-anisidine, provide general or local exhaust ventilation and dilution.

**REGULATORY INFORMATION (o-Anisidine):** CA2; Sf3, T30-e10; T120-d10; CAL; Reportable Quantity (RQ): 100lbs (45.4kg); (p-Anisidine): Sf3; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** o-anisidine is used as an intermediate in the manufacture of azo dyes and in the production of Solvent Red 1; used to prepare guaiacol via diazotization and hydrolysis; p-anisidine is used in the manufacture of azo dyes and as a chemical intermediate for Vat Red 29, Disperse Orange 15, and Azoic Coupling Component 13.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 13, 14, 15.

### **ANTIMONY AND COMPOUNDS: (Sb, 121.75)**

**CAS/DOT IDENTIFICATION #:** 7440-36-0/UN2871

**SYNONYMS:** antimony black, antimony metal, antimony powder, stibium.

**PHYSICAL PROPERTIES:** silvery-white metal; lustrous, hard brittle metal; insoluble in water; soluble in hot, concentrated sulfuric acid; MP (630°C, 1166°F); BP (1635°C, 2975°F); DN (6.684 g/mL at 25°C); SG (6.69); HV (195,000 J/mol); VP (1mmHg at 886°C).

**CHEMICAL PROPERTIES:** noncombustible solid; will not polymerize; slightly oxidized in air; reacts vigorously with strong oxidizers, strong acids, halogenated acids, chlorine, and fluorine; FP (NO DATA); LFL/UFL (NO DATA).

**EXPLOSION and FIRE CONCERNS:** moderate fire and explosion hazard in forms of dust and vapor; when heated or on contact with acid, emits toxic fumes of SbH<sub>3</sub>; electrolysis of acid sulfides and antimony halides yields explosive antimony; reacts violently with ammonium nitrate, halogens, bromine azide, chloric acid, chlorine oxide, chlorine trifluoride, nitric acid, potassium nitrate, potassium permanganate, potassium peroxide, sodium nitrate, and oxidants; use appropriate extinguishing media for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes and lungs, stomach pain, diarrhea, vomiting, stomach ulcer); ingestion (vomiting, gastrointestinal upset).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** no data available; 25ppm in water poses a hazard to man.

**ACUTE HEALTH RISKS:** irritation to eyes, skin, nose; cardiovascular effects; liver and kidney damage; gastrointestinal effects; stomach pain; vomiting; diarrhea; hair loss; fatigue.

**CHRONIC HEALTH RISKS:** respiratory effects; chronic bronchitis; chronic emphysema; inactive tuberculosis; increased blood pressure; heart muscle damage; gastrointestinal effects; dermatitis; disturbances in menstrual cycle.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg(Sb)/m<sup>3</sup>; OSHA PEL TWA 0.5(Sb)mg/m<sup>3</sup>; NIOSH REL TWA 0.5(Sb)mg/m<sup>3</sup>; IDLH 50mg(Sb)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear appropriate chemical protective gloves, boots, and goggles; wear a filter mask or self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as fly ash or cement powder; do not use water on material itself and keep out of water sources and sewers.

**DISPOSAL AND STORAGE METHODS:** dissolve in minimum concentrated hydrochloric acid; dilute with water until white precipitates form and add 6M hydrochloric acid to redissolve; saturate with hydrogen sulfide, filter, wash, dry; transport material back to supplier to recover the heavy metal content and deactivate; alternatively, material can be encapsulated and buried in a sanitary landfill; do not store near foodstuffs.

**REGULATORY INFORMATION:** S1; S23; S32-53; S51; S62; R2-1; R4; R6; R8; Reportable Quantity (RQ): 5000lbs (2270kg); Sf1; Sf3; CW5; T120-a; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used in the manufacture of white metal, bullets, thermoelectric piles, medicines; chemical intermediate for fire retardant compounds, ceramics, glass additives, and paint pigments.

**KEY REFERENCES:** 4; 5; 6; 11; 12; 13.

## **ANTU (C<sub>11</sub>H<sub>10</sub>N<sub>2</sub>S, 202.29)**

**CAS/DOT IDENTIFICATION #:** 86-88-4/UN1651

**SYNONYMS:**  $\alpha$ -naphthylthiocarbamide,  $\alpha$ -naphthylthio-urea, 1-naphthylthiourea, 1-(1-naphthyl)-2-thiourea.

**PHYSICAL PROPERTIES:** white crystalline or gray powder; odorless; bitter taste; slightly soluble in water; soluble in acetone and triethylene glycol; fairly soluble in hot alcohol; MP (198°C, 388°F); BP (de-composes); DN (> 1 g/cm<sup>3</sup>); SG (unknown); VP (low).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with strong oxidants; incompatible with silver nitrate; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; combustible under specific conditions; risk of fire and explosion on contact with strong oxidizers; not compatible with silver nitrate; decomposes on heating, producing toxic fumes of oxides of nitrogen and sulfur oxides; use powder, alcohol foam, water spray or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (pulmonary edema, bluish discoloration of skin, difficult in breathing, shortness of breath); ingestion (abdominal pain, vomiting, coarse pulmonary rales, liver damage); skin contact (may cause dermatitis).

## 414 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with large amounts of soap and water; if breathing is difficult, remove to fresh air; if breathing has stopped, perform respiratory support; in case of ingestion, give a slurry of activated charcoal in water to drink; induce vomiting and get immediate medical attention.

**HUMAN TOXICITY DATA:** unreported-man LDLo 588 mg/kg.

**ACUTE HEALTH RISKS:** labored breathing; shortness of breath; cyanosis; abdominal pain; vomiting; lung edema; mild liver damage; death caused by pulmonary edema.

**CHRONIC HEALTH RISKS:** prolonged contact with skin may cause dermatitis; chronic toxicity has been reported to cause a decrease in white blood cells.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.3 mg/m<sup>3</sup>; OSHA PEL TWA 0.3 mg/m<sup>3</sup>; NIOSH REL TWA 0.3 mg/m<sup>3</sup>; IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust proof-safety goggles or face shields; a system of local exhaust ventilation is recommended to control emissions at the source and to pre-vent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing apparatus; for extra personal protection, use a P3 filter respirator for toxic particles; maintain eyewash bath and quick drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; moisten first to prevent dusting; collect remaining material, then remove to a safe place.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substance into sealable containers, and place in a secured sanitary landfill; store in a cool, dry location; use only with adequate ventilation; separate from strong oxidants, strong bases, silver nitrate, food and feedstuffs.

**REGULATORY INFORMATION:** R4; P waste # (P072); Report-able Quantity (RQ): 100 lbs (45.4kg); SF1; Sf2; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a rodenticide, specifically for control of the adult Norway rat; lower toxicity with regard to other rat species.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

### **ARSENIC, inorganic compounds (As, 74.92)**

**CAS/DOT IDENTIFICATION #:** 7440-38-2/1558

**SYNONYMS:** arsenic black, arsenic 75, colloidal arsenic, gray arsenic, metallic arsenic.

**PHYSICAL PROPERTIES:** silvery to black, crystalline amorphous metalloid; brittle; when heated gives off fumes of garlic; soluble in nitric acid; insoluble in water; insoluble in caustic and nonoxidizing acids; MP (814°C, 1135°F); BP (sublimes at 612°C); DN (black crystals 5.727 g/mL at 14°C); SG (5.73); HV (11.2kcal/g-atom); VP (1mmHg at 372°C, 40mmHg at 483°C, 100mmHg at 518°C).

**CHEMICAL PROPERTIES:** noncombustible solid in bulk form; darkens in moist air; reacts vigorously with strong oxidizers, bromine azide; reacts with nitric acid; attacked by hydrochloric acid in presence of oxidants; low thermal conductivity; FP (NO DATA); LFL/UFL (NO DATA); HS (30.5 kcal/g-atom); HF (22.4 kcal/g-atom).

**EXPLOSION and FIRE CONCERNS:** flammable in the form of dust when exposed to heat or flame; when heated or on contact with acid or acid fumes, it emits highly toxic fumes; dangerous when water solutions of arsenicals are in contact with active metals such as iron, zinc, aluminum; flammable by chemical reaction with bromates, chlorates, iodates, peroxides, lithium, silver nitrate, nitric acid, potassium permanganate, chromium trioxide, chlorine trifluoride, chlorine oxide, bromine trifluoride, bromine pentafluoride, bromine azide; use foam, carbon dioxide, or dry chemical for firefighting purposes..

**HEALTH SYMPTOMS:** inhalation (sore throat and irritated lungs); skin contact (redness and swelling); ingestion (gastrointestinal effects, vomiting, diarrhea, shock).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; if ingested, induce vomiting with syrup of ipecac; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-man TDLo 76mg/kg/12Y-I:CAR; oral-man TDLo 7857mg/kg/55Y; EPA Cancer Risk Level (1 in a million excess lifetime risk)  $2 \times 10^{-7}$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** gastrointestinal effects; abdominal pain; nausea; diarrhea; vomiting; headaches; weakness; delirium; anemia; leukopenia; decreased production of red and white blood cells; cardiovascular system effects; abnormal heart rhythm; blood vessel damage; hypotension; liver, kidney and blood effects; shock; death.

**CHRONIC HEALTH RISKS:** irritation of skin and mucous membranes; dermatitis; rhinitis; pharyngitis; conjunctivitis; skin lesions; hyper-pigmentation; gangrene of the extremities; vascular lesions; exfoliation; herpes; appearance of small corns or warts; increased risk of nonmelanoma skin cancer; lung cancer; bladder and liver cancer; tumors of mouth, esophagus, larynx, bladder, para nasal sinus; liver or kidney damage; lower than normal birth weights.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg(As)/m<sup>3</sup>; OSHA PEL TWA 0.01(As)mg/m<sup>3</sup>; NIOSH REL CL 2 $\mu$ g(As)/m<sup>3</sup>/15M; IDLH 5mg(As)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing (long-sleeved coveralls, boots, gloves, etc.); wear safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to "knock down" dust; use sol-vent extraction with high molecular-weight amines and quaternary ammonium compounds for the removal of arsenic from industrial effluents.

**DISPOSAL AND STORAGE METHODS:** dissolve in minimum concentrated hydrochloric acid; dilute with water until white precipitates form; add 6M hydrochloric acid to redissolve; saturate with hydrogen sulfide, filter, wash and dry, and ship to supplier or place in a sanitary landfill; store in cool, dry well-ventilated area.

**REGULATORY INFORMATION:** S1; S11; R1; R2-2; R4; R7; D waste # (D004); Sf1; Sf3; CW5; A4; CAL; Dot hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in wood preservation; used as a weed killer; used in the production of insecticides, herbicides, rodenticides, defoliants, and desiccants; used in the treatment of syphilis, psoriasis, and as an antiparasitic agent in veterinary medicine; used in the manufacture of battery grids, cable sheaths, glass, and boiler tubes.

**KEY REFERENCES:** 4; 5; 6; 11; 12; 13; 15.

**ARSENIC, ORGANIC COMPOUNDS (as As)** (Organic arsenic compounds have variable molecular formulas and variable formula weights depending upon the specific organic arsenic compound. The molecular formula for arsenic is As. Its corresponding formula weight is 74.92).

**CAS/DOT IDENTIFICATION #:** Organic arsenic compounds have variable CAS #'s. The CAS # for arsenic is 7440-38-2. The DOT identification numbers for metallic arsenic and arsenic dust are 1558 and 1562, respectively.

**SYNONYMS:** Synonyms vary depending upon the specific organic arsenic compound.

**PHYSICAL PROPERTIES:** Appearance and odor vary depending upon the specific organic arsenic compound. Physical properties of specific compounds are provided for illustrative purposes. (arsenic diethyl) liquid or oil; BP (185-190°C, 365-374°F); DN (about 1.0 g/mL); SG (about 1.0). (arsenic dimethyl) colorless to yellow oily liquid; MP (-6°C, 21.2°F); BP (186°C, 366.8°F); DN (1.15 g/mL); SG (1.15). (arsenoacetic acid) minute yellow needles; does not melt below 260°C (500°F); decomposition begins at about 205°C (401°F); readily soluble in pyridine, dilute sodium carbonate and dilute sodium hydroxide solutions; insoluble in water and common organic solvents.

**CHEMICAL PROPERTIES:** Properties vary depending on the specific organic arsenic compound.

**EXPLOSION and FIRE CONCERNS:** arsenic diethyl is a dangerous fire hazard by spontaneous chemical reaction; dangerous when heated; incompatible with oxidizing materials; arsenic dimethyl is flammable and emits dangerous fumes of arsenic when heated; extinguish small fires using dry chemical, carbon dioxide, water spray, or foam; for large fires, use water spray, fog or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (respiratory distress, irritates eyes, skin and respiratory system); skin contact (possible dermatitis, allergic reactions, itching, pigmentation, cancerous changes); ingestion (loss of appetite, cramps, nausea, constipation, diarrhea, liver damage (resulting in jaundice)).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; flush affected areas of skin with large amounts of soap and water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no LD50/LC50 information found related to normal routes of occupational exposure; Toxicity data, as referred to metallic arsenic, is as follows: oral-man TDLo 76mg/kg/12Y-intermittent; toxic effect: carcinogenic; oral-man TDLo 7857 mg/kg/55Y; toxic effect: skin; oral-man TDLo 7857 mg/kg/55Y; toxic effect: gastrointestinal tract.

**ACUTE HEALTH RISKS:** based on testing in animals, may cause irritation of skin, respiratory distress, diarrhea, kidney impairment, muscle tremor, seizure, and possible effects on the gastrointestinal tract.

**CHRONIC HEALTH RISKS:** based on testing in animals, may cause possible liver and kidney damage; reproductive and teratogenic effects have been reported, based on testing in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (no information found); OSHA PEL TWA 0.5 mg/m<sup>3</sup>; NIOSH REL TWA (none); IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron, or long-sleeved coveralls; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in high concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** apply water spray or mist to knock down vapors; absorb bulk liquid with fly ash, cement powder, or commercial sorbents; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** arsenic organic compounds should be disposed of in accordance with federal, state, and local regulations; store in a cool, dry location; keep in a well-ventilated room; storage should be in well closed containers.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (none); label (none required).

**OTHER COMMENTS:** used in wood preservation; used as a weed killer; used in the production of insecticides, herbicides, rodenticides, defoliants, and desiccants; used in the treatment of syphilis, psoriasis, and as an antiparasitic agent in veterinary medicine; used in the manufacture of battery grids, cable sheaths, glass, and boiler tubes.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 14.

### **ARSINE(AsH<sub>3</sub>, 77.95)**

**CAS/DOT IDENTIFICATION #:** 7784-42-1/UN2188

**SYNONYMS:** arsenic hydride, arsenic trihydride, hydrogen arsenide.

**PHYSICAL PROPERTIES:** colorless gas; mild, garlic-like odor; soluble in water, benzene, and chloroform; slightly soluble in ethyl alcohol and alkalies; MP (-117°C, -179°F); BP (-62°C, -81°F); Gas DN (2.695 g/L); VS (0.01458 mPa-s at 0°C); VD (2.66); VP (14.9 atm at 70°F).

**CHEMICAL PROPERTIES:** stable; will not polymerize; very little tendency to protoxide; reacts vigorously with strong oxidizers, chlorine, and nitric acid; reacts with light to deposit arsenic; LFL/UFL (5.1%, 78%).

**EXPLOSION and FIRE CONCERNS:** flammable gas; NFPA rating Health 4, Flammability 4; Reactivity 2; moderately explosive when exposed to chlorine, nitric acid, open flame, or powerful shock; incompatible or reacts strongly with oxidizing materials, acids and halogens; decomposes at 572°F (300°C) with deposition of arsenic; gas is heavier than air and may travel to a source of ignition and flash back; closed containers may rupture violently when heated; use fine spray or fog, alcohol foam, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, weakness, malaise, and dizziness); skin absorption (respiratory system, nausea, vomiting).

**FIRST AID:** do not rub the affected areas or flush them with water if frostbite has occurred; provide respiratory support.

## 418 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**HUMAN TOXICITY DATA:** inhalation-human TCLo 3ppm: RBC; inhalation-human LCLo 25ppm/30M; inhalation-man TDLo 338 ppt; EPA Cancer Risk (1 in a million excess life-time risk):  $2 \times 10^{-7}$ mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** headache; nausea; vomiting; tightness of chest; pain in abdomen and loins; kidney failure; jaundice; hemolytic anemia; extreme acute toxicity; death.

**CHRONIC HEALTH RISKS:** hemolysis; abnormal blood cell morphology; anorexia; hematemesis; paresthesia; renal failure; pulmonary edema; increase in spontaneous abortion rate.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05 ppm; OSHA PEL TWA 0.05 ppm (0.2mg/m<sup>3</sup>); NIOSH REL CL 0.002 mg/m<sup>3</sup>/15M; IDLH 3ppm.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus; wear protective clothing and safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; may be removed from process-ventilated exhaust air from copper electrolytic purification cells by counter-current wet scrubbing; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** implement land disposal of waste residue (including waste sludge); store in a cool, dry, well-ventilated location; outside storage is preferred.

**REGULATORY INFORMATION:** Sf2; A1; A2; CAL; DOT hazard class/division (2.3); labels (poison gas, flammable gas).

**OTHER COMMENTS:** used in the microelectronic industry; used in the manufacture of semiconductors.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13.

**ASBESTOS** ( $[\text{Mg}_6(\text{Si}_4\text{O}_{10})(\text{OH})_8]$ , N/A)

**CAS/DOT IDENTIFICATION #:** varies with compound/NA2212

**SYNONYMS:** actinolite, chrysotile, tremolite.

**PHYSICAL PROPERTIES :** a group of six different minerals occurring naturally in the environment; most common type is white; others are blue, gray, or brown; long, thin fibers similar to fiberglass; small fibers may occur in suspension in both air and water; insoluble; nonvolatile; serpentine asbestos is formed from chrysotile mineral and characterized by strong, flexible fibers for spinning; amphibole asbestos is characterized by brittle fibers and is resistant to chemicals and heat; MP (1112°F); VP(0 mmHg).

**CHEMICAL PROPERTIES:** noncombustible; fire-resistant fibers.

**EXPLOSION and FIRE CONCERNS:** material itself does not burn or burns with difficulty; no incompatibilities or reactivities reported; common air contaminant; use agent suitable for type of surrounding fire for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes and respiratory system).

**FIRST AID:** wash eyes immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCl<sub>0</sub> 1.2 fibers/cc/19Y-C: pul; EPA Cancer Risk Level (1 in a million excess lifetime risk): 4 fibers/cm<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes and respiratory system; interstitial fibrosis.

**CHRONIC HEALTH RISKS:** asbestosis (lung disease); diffuse fibrous scarring of the lungs; coughing; shortness of breath; pulmonary hypertension; lung cancer; cancer of the bronchus and or pharynx; cancer of the stomach; cancer of the esophagus; clubbing of the fingers; "asbestos bodies" found in sputum and alveolar walls; death; EPA Group A: human carcinogen (cancer causing agent).

**EXPOSURE GUIDELINES:** ACGIH TLV 2 fibers>5μm/cm<sup>3</sup> (chrysotile and other forms of asbestos); ACGIH TLV 0.5 fibers>5μm/cm<sup>3</sup>; ACGIH TLV 0.1 fiber < 5μm/cm<sup>3</sup> (crocidolite); OSHA PEL 0.2 fibers> 5μm/cm<sup>3</sup>; NIOSH REL 0.1 fiber<5μm/cm<sup>3</sup>.

**PERSONAL PROTECTION:** wear an appropriate self-contained breathing apparatus with a full-facepiece.

**SPILL CLEAN-UP:** the concentration of asbestos fibers in drinking water can be removed by granular media filtration; asbestos cement pipes can be coated with a chemical precipitate to avoid the release of fibers from dissolution and leaching effects.

**DISPOSAL AND STORAGE METHODS:** place in a sanitary landfill; consult with environmental regulatory agencies for guidance on acceptable disposal practices.

**REGULATORY INFORMATION :** CA2; S1; S23; S32; S51; S62; Sf1; Sf3; CW3; T120-C6; A1; A4; CAL; DOT hazard class/division (9); labels (class 9); Reportable Quantity (RQ): 11b (0.454 kg)..

**OTHER COMMENTS:** used in fireproof fabrics, roofing compositions, electrical and heat insulations, brake lining, and paint filler.

**KEY REFERENCES:** 3; 4; 5; 6; 11; 12; 13; 14.

### **AZINPHOS-METHYL (C<sub>10</sub>H<sub>12</sub>N<sub>3</sub>O<sub>3</sub>PS<sub>2</sub>, 317.34)**

**CAS/DOT IDENTIFICATION #:** 86-50-0/UN2783

**SYNONYMS:** benzotriazine dithiophosphoric acid dimethoxy ester, S-(3,4-dihydro-4-oxo-1,2,3-benzotriazin-3-ylmethyl)-0,0-dimethyl phosphorodithio-ylmethyl phosphorodithioate, guthion<sup>®</sup>, methyl azinphos.

**PHYSICAL PROPERTIES :** colorless crystals or brown, waxy solid; slightly soluble in water; soluble in methanol, ethanol, chloroform, propylene glycol, toluene, xylene, and other organic solvents; MP (73-74°C, 163-165°F); BP (decomposes); DN (1.44 g/cm<sup>3</sup> at 20°C); SG (1.44); VP (8 x 10<sup>-9</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; solutions in ethanol and propylene glycol are stable for at least three weeks; unstable at temperatures >200°C (392°F); will hydrolyze under influence of acids and cold alkali; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; liquid formulations containing organic solvents may be flammable; characteristics of the dust or the solvent used in the formulation will determine the explosion hazard; decomposes in acid or base; decomposes on heating above 200°C (392°F), producing toxic and corrosive fumes of nitrogen oxides, phosphorous oxides, and oxides of sulfur; use dry powder, alcohol foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (convulsions, dizziness, nausea, vomiting, pupillary constriction, muscle camp, excessive salivation, unconsciousness); skin absorption (sweating, twitching, paralysis, headache, dizziness, convulsions, other symptoms parallel those of inhalation); eye contact (tearing, small pupils, blurred vision, aching eyes); diarrhea, labored breathing, blurred vision, loss of consciousness).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush skin immediately with large amounts of soap and water; if breathing is difficult, provide respiratory support; in case of ingestion, induce vomiting and get immediate medical attention.

**HUMAN TOXICITY DATA:** cytogenetic analysis-human lung 120 mg/L; cytogenetic analysis-human other cell types 120 mg/L.

**ACUTE HEALTH RISKS:** dizziness, headache; chest tightness; wheezing; laryngeal spasms; excessive salivation; miosis; pupillary constriction; blurred vision; aching eyes; lacrimation; rhinorrhea; cyanosis; nausea; vomiting; diarrhea; sweating; twitching; muscle cramp; paralysis; low blood pressure; convulsions; cardiac irregularities; loss of consciousness; respiratory failure; death in high concentrations.

**CHRONIC HEALTH RISKS:** cholinesterase inhibitor; cumulative effect of acute hazards is possible.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.2 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.2 mg/m<sup>3</sup> (skin); IDLH 10 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use dust-proof safety goggles in combination with breathing protection if powder; a system of local exhaust ventilation or breathing protection is preferred if not powder; for extra personal protection, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in general work area.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; moisten first to prevent dusting; collect remaining material, then remove to safe place; wash spill area with large amounts of water but not into confined spaces such as sewers.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substance into sealable containers, and place in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; keep in a well-ventilated room isolated from strong oxidizers, acids, and bases; separate from food and feedstuffs.

**REGULATORY INFORMATION:** F1; Sf2; A1; CAL; DOT hazard class/division (6.1); labels (do not transport with food and feedstuffs).

**OTHER COMMENTS:** used as an insecticide for fruit; use may be restricted; substance may be hazardous to the environment; special attention should be given to fish.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

**BARIUM(Ba, 137.36)****CAS/DOT IDENTIFICATION #:** 7440-39-3/UN1400**SYNONYMS:** bario (spanish), baryum (french).

**PHYSICAL PROPERTIES :** yellowish-white, slightly soluble lustrous lumps; silver-white; somewhat malleable; body-centered cubic structure; dissolves in water forming barium hydroxide solutions; soluble in ammonia, forming a blue-black solution; insoluble in benzene; MP (725°C); BP (1640°C); DN (3.5 g/mL at 20°C); LSG (3.51); ST (224 dynes/cm at 720°C); VP (10mmHg at 1049°C).

**CHEMICAL PROPERTIES:** extremely reactive; reacts readily with water, ammonia, halogens, oxygen, and most acids; reactions are characteristic of alkaline earth metals; soluble salts give a white precipitate with sulfuric acid; gives green color in flame; very easily oxidizable.

**EXPLOSION and FIRE CONCERNS:** flammable at room temperature in powder form; NFPA rating Health 2, Flammability 2, Reactivity 0; dust is dangerous and explosive when exposed to heat, flame, or chemical reaction; reacts violently with water, carbon tetrachloride, fluorotrichloromethane, and trichloroethylene; reacts violently when heated to approximately 200°C in hydrogen, forming barium hydride; incompatible with acids, halogens, and water; may ignite or explode in air or other oxidizing gases; use large amounts of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, and throat); skin absorption (respiratory system, slow pulse, muscle spasm).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** fatal dose to man is 550 mg.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory system.

**CHRONIC HEALTH RISKS:** slow, irregular pulse; transient hypertension; convulsive tremors; muscular paralysis; vomiting; diarrhea; colic; death.

**EXPOSURE GUIDELINES:** OSHA PEL TWA 0.5mg/m<sup>3</sup>; ACGIH TLV TWA 0.5mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear rubber gloves, rubber protective clothing and aprons; wear chemical safety goggles; wear an appropriate gas-filter mask.

**SPILL CLEAN-UP:** dissolve in 6M hydrochloric acid and filter; neutralize with 6M ammonium hydroxide and precipitate with excess sodium carbonate; filter, wash, dry, and ship to supplier; install exhaust ventilation to reduce dust concentration.

**DISPOSAL AND STORAGE METHODS:** absorb liquid form in dry earth or sand and place in a sanitary landfill; separate from acids, combustibles, and ammonium compounds; store in a cool, dry, well-ventilated location.

**REGULATORY INFORMATION :** S1; S23; S32; S51; S62; R1; R2-03; R4; R6; R8; D waste # (D005); Reportable Quantity (RQ): NA; Sf3; CAL; DOT hazard class/division (4.3); labels (dangerous when wet).

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**OTHER COMMENTS:** used as getter alloys in vacuum tubes; used as a lubricant for anode rotors in x-ray tubes and spark-plug alloys; used as a carrier for radium.

**KEY REFERENCES:** 3; 5; 6; 7; 11; 12; 14.

### **BARIUM SULFATE (BaSO<sub>4</sub>, 233.39)**

**CAS/DOT IDENTIFICATION #:** 7727-43-7/UN1564

**SYNONYMS:** artificial barite, barite, barium salt of sulfuric acid, barytes (natural), blanc fixe, enamel white, microbar, neobar, oratrast, polybar, telebar.

**PHYSICAL PROPERTIES:** fine, heavy white powder or polymorphous crystals; odorless; tasteless; undergoes transition from orthorhombic to monoclinic phase at 11°C (51.8°F); soluble in hot concentrated sulfuric acid; practically insoluble in water, dilute acids, and alcohol; particle size may vary from 2-25 microns; MP (1580°C, 2876°F); BP (1600°C, 2912°F decomposes); DN (4.25-4.5 g/cm<sup>3</sup>); SG (4.25-4.5); CP (101.8 J/K-mol crystal at 25°C); VD (no information found); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; decomposes above 1600°C (2912°F); 5% in water is neutral to litmus; emits toxic fume of oxides of sulfur upon decomposition; FP (NA); LFL/UFL (NA); AT (NA); HF (-1473.2 kJ/mol crystal at 25°C); H<sub>f</sub> (40.6 kJ/mol at 1623K).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating Health 0, Flammability 0, Reactivity 0; not considered to be a fire hazard; not considered to be an explosion hazard; heating with aluminum can cause an explosion; incompatible with aluminum and phosphorus; burning may produce oxides of sulfur; use any means suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (benign pneumoconiosis, irritates upper respiratory tract); skin contact (no adverse effects expected); eye contact (no adverse effects expected but many case mechanical irritation); ingestion (not expected to be a health hazard).

**FIRST AID:** wash eyes thoroughly with running water; wash affected areas of the skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if large amounts were swallowed, drink several glasses of water and get medical advice.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and upper respiratory system; not expected to be a health hazard.

**CHRONIC HEALTH RISKS:** deposition of sufficient quantities of dust in lungs may lead to baritosis - a benign pneumoconiosis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; use chemical safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; half-face

dust/mist respirators are needed in areas where exposure would be above the permissible exposure level; use positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; sweep up and containerize for proper disposal; use vacuuming or wet sweeping to avoid dust dispersal.

**DISPOSAL AND STORAGE METHODS:** manage whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry location; maintain adequate ventilation; keep in tightly closed containers and protect against physical damage; isolate from sources of heat, moisture, and incompatibilities.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used in the manufacture of cellophane and photographic papers; useful as a filler for rubber, linoleum, textiles, plastics, and lithograph inks; also used as a water-color pigment for colored paper and in wallpaper; other uses include x-ray photography and as an opaque medium for gastrointestinal radiography.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **BENOMYL (C<sub>14</sub>H<sub>18</sub>N<sub>4</sub>O<sub>3</sub>, 290.36)**

**CAS/DOT IDENTIFICATION #:** 17804-35-2/UN2757

**SYNONYMS:** 1-(butylcarbamoyl)-2-benzimidazolecarbamic acid methyl ester, dupont 1991, fundasol, fungicide 1991, methyl-1-(butylcarbamoyl)-2-benzimidazolecarbamate.

**PHYSICAL PROPERTIES :** white, crystalline solid; faint, acrid odor; very slightly soluble in water; soluble in ethanol, heptane, chloroform, xylene, acetone, and dimethylformamide; MP (300°C, 572°F); BP (decomposes); DN (data not available); SG (data not available); VD (data not available) VP (<0.1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; dissociates in some solvents to form carben-dazim and butyl isocyanate; decomposes in aqueous solution to methyl n-(benzimidazolyl) carbamate and the ethyl analog; decomposes without melting above 300°C (572°F); decomposed by strong acids and strong alkalies; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; substance itself does not burn but may decompose upon heating; NFPA rating (not published); containers may explode when heated; non-volatile at room temperature; subject to decomposition on storage in presence of moisture; incompatible with strong acids and alkaline materials; toxic gases, such as oxides of nitrogen, may be released in a fire; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory tract); contact (skin sensitization, redness, skin rash, skin allergies); ingestion (nausea, vomiting, abdominal cramps, salivation, reproductive effects).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with large amounts of soap and water; if breathing is difficult, give oxygen; if breathing has stopped, perform artificial respiration; in case of ingestion, drink large amounts of water and induce vomiting by giving syrup of ipecac; seek medical attention.

**HUMAN TOXICITY DATA:** skin-man 0.1%; reaction: mild; cytogenetic analysis-human HeLa cell 100 $\mu$ mol/L; cytogenetic analysis-human liver 100 $\mu$ mol/L; cytogenetic analysis-human lymphocyte 10mg/L; sister chromatid exchange-human lymphocyte 250 $\mu$ g/L; micronucleus test-human lymphocyte 10mg/L; sex chromosome loss/non-disjunction-human lymphocyte 1 mg/L; other mutation test systems-human lymphocyte 2 mg/L.

**ACUTE HEALTH RISKS:** irritation to eyes and upper respiratory tract; can cause skin irritation and rash; nausea; vomiting; abdominal cramps; salivation; sweating; lassitude (weakness); muscular incoordination; angina pectoris; central nervous system depression; reproductive effects; cholinesterase inhibition.

**CHRONIC HEALTH RISKS:** may cause skin sensitization with irritation, redness, and cholinesterase inhibition; may cause mutations (genetic changes) in living cells; may possibly cause reproductive damage in humans; may be a teratogen in humans; damages the male reproductive system; decreases sperm count in animals; may cause a skin allergy.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.84 ppm (10mg/m<sup>3</sup>); OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL (no recommended exposure limit for benomyl); IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; chemical-safety goggles or face shields; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing apparatus; maintain eyewash bath and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; for dry spills, use a vacuum or moisten to reduce dust dispersion, and place into dry, sealable containers; absorb liquid spills with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container.

**DISPOSAL AND STORAGE METHODS:** powdered material may be deposited in sealed containers, and then placed in a specified landfill site; containers that are not to be reused should be punctured and transported to a scrap metal facility for recycling, disposal or burial in secured, sanitary landfill; absorb liquid in sand or inert absorbent, and place in a designated landfill; store in a cool, dry location; maintain adequate ventilation; keep dry during storage to avoid certain chemical changes affecting fungicidal effectiveness; store in tightly closed containers; should be stored separately from strong acids, strong alkalies, heat, sparks, and open flame.

**REGULATORY INFORMATION:** F2; F7; F8; R4; U waste # (U271); Sf1; Sf3; A1; CAL.

**OTHER COMMENTS:** used as a fungicide and as an ascaricide; effective against a wide range of fungi affecting field crops, fruits, nuts, ornamentals and turf; used as pre- and post-harvests sprays for control of storage rots of vegetables and fruits; also used as an oxidizer in sewage treatment.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 15; 16; 18.

## **BENZENE (C<sub>6</sub>H<sub>6</sub>, 78.12)**

**CAS/DOT IDENTIFICATION #:** 71-43-2/UN1114

**SYNONYMS:** annulene, benzole, coal naphtha, cyclohexatriene, phenyl hydride.

**PHYSICAL PROPERTIES:** clear, colorless liquid; aromatic odor; negligible solubility in water; miscible with alcohol, ether, acetone, and carbon tetrachloride; MP (6°C, 42.8°F); BP (80°C, 176°F); DN (0.8787 g/mL liquid at 15°C); LSG (0.88 at 20°C); ST (28.22 dynes/cm at 25°C); VS (0.604 mPa-s at 25°C); CP (136.3 J/K-mol liquid at 25°C); HV (33.83 kJ/mol at 25°C); VD (2.77); VP (1mmHg at 36.7°C, 74.6 mmHg at 20°C); OT (1.5 ppm).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react vigorously with strong oxidizing agents, sulfuric acid, nitric acid, chlorine, oxygen, ozone, permanganates, peroxides, and perchlorates; FP (-11°C, 12°F); LFL/UFL (1.2%, 7.8%); AT (498°C, 928°F); HC (-9.698 cal/g, -406.0 x 10<sup>3</sup> J/kg); HF (49.1 kJ/mol liquid at 25°C); H<sub>f</sub> (9.95 kJ/mol at 278.68K).

**EXPLOSION and FIRE CONCERNS:** extremely flammable liquid; dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 0; vapor/air mixtures are explosive; vapor may explode if ignited in enclosed area; explodes on contact with diborane, bromic pentafluoride, and permanganic acid; forms sensitive explosive mixtures with silver perchlorate, nitric acid, iodine tetrafluoride, and liquid oxygen; ignites on contact with sodium peroxide and water; reacts violently with strong oxidants and halogens causing fire and explosion hazard; incomplete burning can produce carbon monoxide and/or carbon dioxide; use dry chemical, carbon dioxide, foam, steam, or water fog for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, drowsiness, shortness of breath, nausea, convulsions, unconsciousness, irritates eyes, skin and nose); skin absorption (giddiness, staggered gait, fatigue, weakness, respiratory distress, headache, dizziness); contact (defatting of skin, dermatitis); ingestion (sore throat, abdominal pain, nausea, vomiting, bone marrow depression, aspiration into the lungs with risk of chemical pneumonitis).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; flush affected areas of skin with large amounts of soap and water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, give plenty of water to drink; seek medical attention.

**HUMAN TOXICITY DATA:** oral-human TDLo 130 mg/kg; toxic effect: central nervous system; inhalation - human LCLo 20,000 ppm/5 months; inhalation-human TCLo 210 ppm; toxic effect: blood; inhalation-human TCLo 100 ppm/10 years - intermittent; toxic effect: carcinogenic; EPA Cancer Risk Level (1 in a million excess lifetime risk): 1.0 x 10<sup>-4</sup> mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation to eyes, skin, and upper respiratory tract; depression of central nervous system; headache; dizziness; drowsiness; lassitude; weariness; excitation; shortness of breath; sore throat; abdominal pain; nausea; vomiting; chemical pneumonitis; convulsions; exposure to very high levels can result in loss of consciousness and death.

**CHRONIC HEALTH RISKS:** adverse blood effects; bone marrow disease; aplastic anemia; excessive bleeding; damage to immune system; chromosomal aberrations; menstrual disorders; leukemia; substance is carcinogenic to humans; EPA Group A: known human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (32 mg/m<sup>3</sup>); OSHA PEL TWA 1 ppm (3.19 mg/m<sup>3</sup>); OSHA PEL STEL 5 ppm; NIOSH REL TWA 0.1 ppm (0.32 mg/m<sup>3</sup>); NIOSH REL STEL 1 ppm; IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron, sleeves, or coveralls; wear splash-proof safety goggles or face shield; enclose operations and/or use local exhaust ventilation at the site of release; explosion-proof electrical equipment is required, as well as non-sparking handtools; appropriate

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respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** collect leaking and spilled liquid in sealable containers or absorb as much as possible with inert materials, such as dry earth or sand; flush remaining liquid with large amounts of water but not into spaces such as sewers due to possibility of explosion; use water spray to disperse vapor; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; cautiously ignite small amounts in open areas; atomize large amounts in a suitable combustion chamber; store in flammable liquids storage area; outside storage is recommended; keep containers closed; ground and bond containers when transferring materials; separate from strong oxidants and halogens; store away from heat, ignition sources, and open flame.

**REGULATORY INFORMATION:** CA2; S32; S50-a1; S61-a2; S62; S10; R1; R2-18; R3; R4; R5; R7; R8; R9; D waste # (D018); U waste # (U019); Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf3; CW1; CW2; CW3; CW4; CW5; A1; A2; A4; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of dyes, linoleum, varnishes, medicines, cumene, cyclohexane, and sulfonic acid; used as a component in detergents, inks, and adhesives; medical monitoring may be required; special signs may be required in the work area.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14.

**BENZIDINE** (C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>, 184.26)

**CAS/DOT IDENTIFICATION #:** 92-87-5/UN1885

**SYNONYMS:** p-benzene, 4,4'-bianiline, 4,4'-diaminobiphenyl.

**PHYSICAL PROPERTIES :** grayish-yellow, reddish-gray, or white crystalline powder; insoluble in water; darkens on exposure to air and light; MP (117°C, 243°F); BP(400°C, 752°F); DN (1.250 g/cm<sup>3</sup> at 20°C); SG(1.25 at 68°F); VD (6.36); VP(5 x 10<sup>-4</sup> mmHg at 25°C).

**CHEMICAL PROPERTIES:** may be sublimed; forms insoluble salts with sulfuric acid; found as a free base in natural waters; can be diazotized and oxidized; amino groups can be acetylated and alkylated; reacts vigorously with red fuming nitric acid.

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating (not rated); forms explosive mixtures in the air from small, dispersed particles; can ignite by electric sparks; toxic oxides of nitrogen are produced during combustion; incompatible or reacts violently with strong oxidants and red fuming nitric acid; explosion risk above flash point temperature; use dry chemical powder, carbon dioxide, appropriate foam, or a water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (respiratory system, headache, nausea, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; if ingested, wash out mouth with water providing person is conscious and have person drink water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man TCLo 17,600 $\mu\text{g}/\text{m}^3/14\text{Y}$ ; dnd-human: fibroblast 3mmol/L; EPA Cancer Risk Level (1 in a million excess lifetime risk)  $2.0 \times 10^{-8} \text{ mg}/\text{m}^3$ .

**ACUTE HEALTH RISKS:** skin irritation; headaches; nausea; central nervous system depression; cyanosis; mental confusion; vertigo; fatigue; skin rashes; possible heart attack.

**CHRONIC HEALTH RISKS:** secondary anemia; hemolysis; acute cystitis; acute liver disorders; kidney damage; possibly cancerous.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA, confirmed human carcinogen; OSHA TWA, suspected occupational carcinogen; NIOSH TWA, potential human carcinogen.

**PERSONAL PROTECTION:** wear plastic overalls and butyl rubber gloves; use a gas-tight, fireproof suit; wear self-contained positive-pressure breathing apparatus; wear chemical safety goggles.

**SPILL CLEAN-UP:** cover the spill with a 9:1 mixture of sand and soda ash; isolate and remove discharged material but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and dispose of at an EPA-approved disposal site; destroy by potassium permanganate oxidation, high-temperature incineration, or microwave plasma treatment; may be encapsulated by organic polyester resin or silicate fixation; storage should be away from light and strong oxidants.

**REGULATORY INFORMATION :** CA2; R4; R7; R8; U waste # (U021); Reportable Quantity (RQ): 11b (0.454kg); Sf1; Sf3; CW3; CW4; CW5; A1; A4; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of azo dyes; used for the detection of hydrogen cyanide, hydrogen sulfate, and blood stains; used as a hardener in rubber compounds.

**KEY REFERENCES:** 1; 4; 5; 6; 11; 12; 13; 14.

### **BENZOYL PEROXIDE (C<sub>14</sub>H<sub>10</sub>O<sub>4</sub>, 242.24)**

**CAS/DOT IDENTIFICATION #:** 94-36-0/UN2085

**SYNONYMS:** benoxyl, benzoperoxide, benzoyl superoxide, dibenzoyl peroxide, diphenylglyoxal peroxide, dry and clear.

**PHYSICAL PROPERTIES :** colorless to white crystals or a granular powder; faint, benzaldehyde-like odor; tasteless; soluble in benzene, chloroform, and acetone; sparingly soluble in water or alcohol; MP (103-106°C, 217.4-223°F); BP (decomposes explosively); DN (1.334 g/cm<sup>3</sup> at 25°C); SG (1.33); VP (<1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible solid; very stable at ordinary temperatures (25°C); reacts with alcohols, amines, metallic naphthanates, dimethylaniline, and various organic and inorganic acids; initiates vinyl chloride polymerizations; FP (80°C, 176°F); LFL/UFL (NA); AT (176°C, 349°F); HC (1551.7 kcal).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 4, Reactivity 4; easily ignited and burns very rapidly; extremely explosion-sensitive to shock, heat and friction; may cause fire, and explodes on contact with combustibles; containers may explode when heated; explosive reaction on contact with N, N-dimethylaniline, aniline, lithium

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tetrahydroaluminate, dimethyl sulfide, and N-bromosuccinimide and 4-toluic acid; reacts violently with alcohols, amines, various organic or inorganic acids, and polymerization accelerators; violent reaction with charcoal when heated above 50°C; forms explosive mixtures with carbon tetrachloride and ethylene at high temperatures and pressures; vigorous reaction leading to ignition with methylmethacrylate, and vinyl acetate and ethyl acetate; a powerful oxidizer; decomposes explosively above the melting point (103°C) and forms flammable products such as benzoic acid, phenyl benzoate, biphenyls, terphenyls, benzene and carbon dioxide; use water spray or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and tissues of mucous membranes, asthmatic effects, allergic effect); contact (redness of skin and burns, sensitization dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** DNA-damage-human other cell types 100µmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; destructive to tissues of mucous membranes; can cause redness of skin and burns.

**CHRONIC HEALTH RISKS:** asthmatic effects; testicular atrophy and vasodilation; sensitization dermatitis; allergic effects; may alter genetic materials; inadequate evidence of carcinogenicity in humans; overall evaluation: Group 3.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; NIOSH REL TWA 5mg/m<sup>3</sup>; IDLH 1500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear rubber clothing and aprons of non-flammable material; rubber boots should be worn over leather footwear; wear safety goggles and self-contained breathing apparatus; avoid soft metal equipment since mildly corrosive.

**SPILL CLEAN-UP:** may be diluted in some unreactive organic solvent, such as phthalate ester; spilled material may also be mixed with water-wetted vermiculite, swept up, and placed in a plastic container for immediate disposal; spark-generating metals or cellulosic materials (wood, paper, etc.) should not be used for sweeping up spilled material.

**DISPOSAL AND STORAGE METHODS:** submerge in alkali solution, such as 10% sodium hydroxide; add water and flush down drain line when complete; wash empty containers with 10% caustic and burn off residue under controlled conditions; wastes can also be charged with 50% noncombustible material (e.g. dry earth, sand or vermiculite), dried, and burned under controlled conditions; store in a cool location, out of the sun's direct rays; keep away from sparks, open flames, and other sources of heat; avoid shock, rough handling, friction from grinding, etc.; isolate storage is required; separate from acids, alcohols, ethers, reducing agents, and polymerization catalysts.

**REGULATORY INFORMATION:** Sf3; A1; A5; CAL; DOT hazard class/division (NA).

**OTHER COMMENTS:** used as a bleaching agent for flour, fats, oils, and waxes; used as a catalyst for hardening of certain fiberglass resins; useful in the treatment of acne and rosacea; principally an initiator for vinyl chloride polymerizations; also used as a curing agent for silicone rubbers; an agent in the production of cheese.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 14.

**BENZYL CHLORIDE (C<sub>7</sub>H<sub>7</sub>Cl, 126.59)**

CAS/DOT IDENTIFICATION #: 100-44-7/UN1738

**SYNONYMS:** alpha chlorotoluene, chloromethylbenzene, chlorophenylmethane, 4-chlorotoluene.

**PHYSICAL PROPERTIES :** clear, colorless to slightly yellow liquid; unpleasant, pungent, aromatic odor; solubility 10% in ethanol, 10% in ethyl ether, 10% in chloroform, 493 ppm in water at 20°C; MP (-47°C, 52.6°F); BP (179°C, 354°F); DN (1.11 g/mL at 20°C); LSG (1.1 at 20°C); ST (37.5 dynes/cm, 0.0375 N/m at 20°C); VS (0.837 mPa-s at 298.15K); HV (130 Btu/lb, 70cal/g, 2.9 x 10<sup>5</sup> J/kg); VD (4.36); VP (1mmHg at 22°C, 10mmHg at 60.8°C, 40mmHg at 90.7°C, 100mmHg at 114.2°C, 400mmHg at 155.8°C); OT (low 0.0235 mg/m<sup>3</sup>, high 1.55mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** fairly stable; may undergo hazardous polymerization; undergoes a self-condensation reaction in the presence of all common metals (except nickel and lead); reacts with steam and oxidizing agents; FP (67°C, 153°F); LFL/UFL (1.3%, 7.1%); AT (585°C, 1085°F); HC (-12,000 Btu/lb, -6700 cal/g, -280 x 10<sup>5</sup>J/kg).

**EXPLOSION and FIRE CONCERNS:** moderate fire hazard; NFPA rating Health 2, Flammability 2, Reactivity 1; reacts with water or steam to produce toxic and corrosive hydrochloric acid fumes; incompatible or reacts violently with strong oxidizers, acids, copper, aluminum, magnesium, iron, zinc, and tin; releases heat and toxic hydrochloric acid vapors on contact with many metals; use dry chemical powder, carbon dioxide, or appropriate foam for firefighting purposes..

**HEALTH SYMPTOMS:** inhalation (coughing, burning of the throat, headache, dizziness, and weakness); skin absorption (severe burns, eye irritation); ingestion (nausea, vomiting, gastrointestinal damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** dnd-human fibroblast 1mmol/L; dnd-human other cell types 1mmol/L.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory tract; depression of the central nervous system; weeping and twitching of eyelids; slight conjunctivitis; severe skin burns.

**CHRONIC HEALTH RISKS:** susceptible to illnesses similar to colds and allergic rhinitis; disturbances of liver functions; decreased number of leukocytes in blood; pulmonary edema; may cause genetic damage; may cause cancer.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm; OSHA PEL TWA 1ppm (5 mg/m<sup>3</sup>); NIOSH REL TWA 1ppm/15M; IDLH 10ppm.

**PERSONAL PROTECTION:** wear rubberized clothing and gloves; wear splash-pooof goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** apply water spray or mist to knock down vapors; absorb in non-combustible material for proper disposal; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible with materials such as sodium bicarbonate or sand; place in an open incinerator, dump into a closed incinerator

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with afterburner, or dissolve in a flammable solvent; store in a cool, dry, well-ventilated location; outside storage preferred; keep away from oxidizing materials, heat and open flame.

**REGULATORY INFORMATION** : CA2; R4; P waste # (P028); Reportable Quantity (RQ): 100lbs (45.4kg); Sf1; Sf2; Sf3; CW1; CW2; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (6.1); labels (poison, corrosive).

**OTHER COMMENTS**: used in the manufacture of dyes, perfumes, artificial resins, and pharmaceutical products; used as a component in lubricants, plastics, and photographic developers.

**KEY REFERENCES**: 1; 4; 5; 6; 8; 11; 12; 13; 14.

### **BERYLLIUM (Be, 9.01)**

**CAS/DOT IDENTIFICATION #**: 7440-41-7/UN1567

**SYNONYMS**: beryllium-9, metal powder (DOT), glucinum.

**PHYSICAL PROPERTIES** : gray-white metal; hard, brittle; odorless; resembles powdered aluminum; soluble in acids (except nitric) and alkalis; insoluble in cold water and mercury; slightly soluble in hot water; high permeability to x-rays; MP (1278°C, 2332°F); BP (2970°C, 5378°F); DN (1.8477 g/cm<sup>3</sup> at 20°C); SG (1.85); CP (0.437 cal/g°C at 30°C); VP (1mmHg at 1520°C, 10mmHg at 1860°C); BHN (60-125).

**CHEMICAL PROPERTIES**: chemical properties similar to aluminum; high thermal conductivity; metal resistant to attack by acid due to the formation of a thin oxide film; resistant to oxidation at ordinary temperatures; attacked by strong bases with evolution of hydrogen; finely divided or amalgamated metal reacts with hydrochloric acid, dilute sulfuric acid, and dilute nitric acid; HC (-28,000 Btu/lb, -15,560cal/g, -652 x 10<sup>5</sup> J/kg); LH<sub>f</sub> (3.5 kcal/mol).

**EXPLOSION and FIRE CONCERNS**: moderate fire hazard in form of dust and powder, when exposed to flame or by spontaneous chemical reaction; NFPA rating Health 4, Flammability 1, Reactivity 1; slight explosion hazard in the form of powder or dust; mixtures of the powder with carbon tetrachloride or trichloroethylene will flash or spark on impact; reacts incandescently with fluorine or chlorine; decomposition emits very toxic fumes of Beryllium oxide; incompatible with acids, caustics, strong oxidizers, chlorinated hydrocarbons, and molten lithium; use dry sand, dry clay, dry ground limestone, or other methods for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (coughing, shortness of breath, acute or chronic lung disease); contact (dermatitis, acute conjunctivitis).

**FIRST AID**: wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA**: inhalation-human TCLo 300mg/m<sup>3</sup>: pul; dnd-human hla 30µmol/L; EPA Cancer Risk Level (1 in a million excess lifetime risk) 4 x 10<sup>-7</sup> mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS**: shortness of breath; coughing; inflammation of the lungs; loss of appetite; loss of weight; fatigue; dermatitis.

**CHRONIC HEALTH RISKS**: bronchitis; lung fibrosis; pulmonary edema; increase in pulse and respiratory rates; chronic pneumonitis; effects on adrenal gland; acute conjunctivitis; rhinitis; chronic skin ulcers; anorexia; death.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.002 mg/m<sup>3</sup>, suspected human carcinogen; OSHA PEL TWA 0.002 mg/m<sup>3</sup>, CL 0.005 mg/m<sup>3</sup>, Pk 0.025 mg/m<sup>3</sup>/30M; OSHA STEL 0.005 mg/m<sup>3</sup>; NIOSH REL TWA 0.005 mg/m<sup>3</sup>; IDLH 4mg (Be)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective outerwear; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** a high efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amount of carcinogen in exhausted air; contaminated materials can be placed in plastic bags for disposal.

**DISPOSAL AND STORAGE METHODS:** dissolve in minimum 6M hydrochloric acid; neutralize with 6M ammonium hydroxide, boil, and allow precipitate to settle; filter, dry and place in a sanitary landfill; storage should be in impervious containers; keep away from acids, bases, halocarbons, and oxidizing materials.

**REGULATORY INFORMATION :** CA2; Sfl; CW3; A1; DOT hazard class/division (6.1); labels (poison, flammable solid).

**OTHER COMMENTS:** used in consumer products including televisions, x-ray machines, calculators, and computers; used in satellites, aircrafts, tools, and missiles.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14.

## **BISMUTH TELLURIDE, UNDOPED (Bi<sub>2</sub>Te<sub>3</sub>, 800.76)**

**CAS/DOT IDENTIFICATION #:** 1304-82-1/none

**SYNONYMS:** bismuth sesquitelluride, bismuth telluride, bismuth tritelluride, dibismuth tritelluride, tellurobismuthite.

**PHYSICAL PROPERTIES :** gray crystalline (sand-like) solid or hexagonal platelets; insoluble in water; MP (573°C, 1063°F); BP (unknown); DN (7.642 g/cm<sup>3</sup>); SG (7.7); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; reacts vigorously with strong oxidizers, such as chlorine, bromine, and fluorine; decomposes on contact with nitric acid and moisture; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-8 kcal/mol); Resistivity (0.00033 ohm-cm); Thermal conductivities at room temperature ( $\lambda_v=0.015$  watt/cm-deg,  $\lambda_c=1.4 \times 10^{-3}$  watt/cm-deg); Electron mobility (800 cm<sup>2</sup>/volt-sec); Hole mobility (400 cm<sup>2</sup>/volt-sec); Energy gap (0.15 eV).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); moderate fire hazard by spontaneous chemical reaction with strong oxidizing agents (e.g., bromine, chlorine, and fluorine); chemical reaction with powerful oxidizers will cause a slight explosion hazard; reaction with moisture evolves a toxic gas; incompatible with nitric acid; heating to decomposition emits toxic fumes of tellurium; in case of fire in the surroundings, use all extinguishing agents for firefighting purposes; employees must be trained and equipped as stated in OSHA 1910.156 if expected to fight fires.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and upper respiratory system); contact (garlic breath, lung changes may occur).

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**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with large amounts of soap and water; if breathing is difficult, give oxygen; if breathing has stopped, perform mouth-to-mouth resuscitation; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no information found concerning toxicity data in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory system; garlic breath.

**CHRONIC HEALTH RISKS:** long term exposure may damage the lungs (note: it is not known whether the damage is permanent); has not been tested for its ability to affect reproduction and to cause cancer in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>; 5mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust-resistant goggles when working with powders or dust; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators equipped with particulate filters are needed in areas where the exposure would be above the permissible exposure level (PEL); for increased protection use self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** collect spilled material and deposit in sealed containers for disposal in an approved facility; absorb liquid spills with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in chemical waste container; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** use a vacuum or wet method to collect spilled material, and deposit in sealed containers for disposal in a designated landfill; absorb in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, well-ventilated area away from moisture; storage should be in tightly closed containers; must be stored to avoid contact with strong oxidizers, such as chlorine, bromine, and fluorine.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** often used in the manufacture of semiconductors for thermoelectric cooling and power generation.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 15.

### **BORON OXIDE (B<sub>2</sub>O<sub>3</sub>, 69.62)**

**CAS/DOT IDENTIFICATION #:** 1303-86-2/none

**SYNONYMS:** boric anhydride, boric oxide, boron sesquioxide, boron trioxide, diboron trioxide.

**PHYSICAL PROPERTIES :** colorless, semi-transparent lumps or hard, white crystals; vitreous (having the appearance and properties of glass); adsorbs moisture from the air (i.e., hygroscopic); odorless; slightly bitter taste; soluble in alcohol and hot water; slightly soluble in cold water; soluble in glycerol; MP (450°C, 842°F); BP (1860°C, 3380°F); DN (2.46 g/cm<sup>3</sup> crystal); SG (2.46); VD (not applicable); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts slowly with water to form boric acid; FP (NA); LFL/UFL (NA); AT (NA); HF (-1273.5 kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; not expected to be a fire hazard; incandescent reaction when mixed with calcium oxide and put into fused calcium chloride; no information found concerning explosion data; no information found concerning hazardous decomposition productions; use appropriate extinguishing media for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract); skin contact (severe irritation or burns); skin absorption (possible systemic effects); eye contact (severe irritation or burns); ingestion (large quantities may be fatal).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; promptly wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, induce vomiting immediately and get medical attention.

**HUMAN TOXICITY DATA:** no information found concerning toxicity data in humans.

**ACUTE HEALTH RISKS:** irritation of upper respiratory tract; nasal irritation; conjunctivitis; erythema; cough; central nervous system effects.

**CHRONIC HEALTH RISKS:** kidney damage; damage to the liver.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>; NIOSH REL TWA 10 mg/m<sup>3</sup>; IDLH 2000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use dust- and/or splash-proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** with clean shovel, carefully place material into clean, dry container and cover; flush remaining spill with large amounts of water.

**DISPOSAL AND STORAGE METHODS:** manage whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in secure poison area; use with adequate ventilation; keep in tightly closed container; isolate from water.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used in the analysis of silicates to determine silicon dioxide and alkalis; also used in the production of boron, heat-resistant glassware, and as a fire-resistant additive for paints; other uses include electronics, liquid encapsulation techniques, and blowpipe analysis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**2-BUTOXYETHANOL (C<sub>6</sub>H<sub>14</sub>O<sub>2</sub>, 118.20)**

**CAS/DOT IDENTIFICATION #:** 111-76-2/UN2369

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**SYNONYMS:** butyl cellosolve®, butyl oxitol, downanol eb, egbe, etkasolve eb, ethylene glycol monobutyl ether, jeffersol eb.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mobile liquid; mild, ether-like odor; high dilution ratio with petroleum hydrocarbons; miscible in all proportions with many ketones, ethers, alcohols, aromatic paraffins, and halogenated hydrocarbons; soluble in all proportions with acetone, benzene, ethyl ether, carbontetrachloride, n-heptane, and water; MP (-70°C, -94°F); BP (171-172°C, 339.8-341.6°F); DN (0.912 g/mL at 20°C); LSG (0.90); ST (27.4 mN/m at 25°C); VS (2.83 centistokes at 25°C); HV (56.59 kJ/mol at 441.5K); VP (0.76 mmHg at 20°C, 300mmHg at 140°C).

**CHEMICAL PROPERTIES:** combustible; moderately volatile; 0.01 maximum percent acidity by weight; reacts with strong oxidizers and caustics; FP (61°C, 142°F); LFL/UFL (1.1% at 200°F, 12.7% at 275°F); AT (238°C, 460.4°F); HC (-13,890 Btu/lb, -7720 cal/g, -323 x 10<sup>5</sup> J/kg).

**EXPLOSION and FIRE CONCERNS:** combustible liquid when exposed to heat or flame; NFPA rating Health 2, Flammability 2, Reactivity 0; incompatible with oxidizing materials, heat and flame; heating to decomposition emits irritating fumes; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); ingestion or skin contact (headache, nausea, vomiting, dizziness); skin absorption (blood effects, central nervous system depression).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 195 ppm/8H; toxic effect: gastrointestinal tract; inhalation-human TCLo 100 ppm; toxic effect: nose, eye, central nervous system; oral-woman TDLo 600mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; headache; nausea; vomiting; dizziness; skin irritation; blood effects.

**CHRONIC HEALTH RISKS:** nose tumors; unspecified eye effects; central nervous system depression; hemolysis; hemoglobinuria; kidney and liver damage; injury to the lymphoid system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25ppm(skin); OSHA PEL TWA 50 ppm (250mg/m<sup>3</sup>(skin)); NIOSH REL TWA 5ppm (24 mg/m<sup>3</sup>(skin)); IDLH 700 ppm.

**PERSONAL PROTECTION:** wear full protective clothing to prevent body contact with liquid; rubber gloves are recommended; wear safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; absorb as much as possible with materials such as dry earth, sand, or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and dispose of in a secured sanitary landfill; dissolve in a more flammable solvent and atomize in a suitable combustion chamber; store in a cool, dry location with adequate ventilation; keep away from heat, flame, and strong oxidizers.

**REGULATORY INFORMATION:** T120-a; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a solvent for nitrocellulose resins, spray lacquers, quick-drying lacquers, varnishes, enamels, varnish removers, and dry-cleaning compounds; mutual solvent for soluble mineral oils to hold soap in solution, and to improve emulsification; use to make acetate esters as well as phthalate and stearate plasticizers; preferred coupling agent for many water-based coatings.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 11.

## **2-BUTOXYETHANOL (C<sub>8</sub>H<sub>14</sub>O<sub>2</sub>, 118.20)**

**CAS/DOT IDENTIFICATION #:** 111-76-2/UN2369

**SYNONYMS:** butyl cellosolve®, butyl oxitol, dowanol eb, egbe, ektasolve eb, ethylene glycol monobutyl ether, jeffersol eb.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mobile liquid; mild, ether-like odor; high dilution ratio with petroleum hydrocarbons; miscible in all proportions with many ketones, ethers, alcohols, aromatic paraffins, and halogenated hydrocarbons; soluble in all proportions with acetone, benzene, ethyl ether, carbontetrachloride, n-heptane, and water; MP (-70°C, -94°F); BP (171-172°C, 339.8-341.6°F); DN (0.912 g/mL at 20°C); LSG (0.90); ST (27.4 mN/m at 25°C); VS (2.83 centistokes at 25°C); HV (56.59 kJ/mol at 441.5K); VP (0.76 mmHg at 20°C, 300mmHg at 140°C).

**CHEMICAL PROPERTIES:** combustible; moderately volatile; 0.01 maximum percent acidity by weight; reacts with strong oxidizers and caustics; FP (61°C, 142°F); LFL/UFL (1.1% at 200°F, 12.7% at 275°F); AT (238°C, 460.4°F); HC (-13,890 Btu/lb, -7720 cal/g, -323 x 10<sup>5</sup> J/kg).

**EXPLOSION and FIRE CONCERNS:** combustible liquid when exposed to heat or flame; NFPA rating Health 2, Flammability 2, Reactivity 0; incompatible with oxidizing materials, heat and flame; heating to decomposition emits irritating fumes; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); ingestion or skin contact (headache, nausea, vomiting, dizziness); skin absorption (blood effects, central nervous system depression).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 195 ppm/8H; toxic effect: gastrointestinal tract; inhalation-human TCLo 100 ppm; toxic effect: nose, eye, central nervous system; oral-woman TDLo 600mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; headache; nausea; vomiting; dizziness; skin irritation; blood effects.

**CHRONIC HEALTH RISKS:** nose tumors; unspecified eye effects; central nervous system depression; hemolysis; hemoglobinuria; kidney and liver damage; injury to the lymphoid system.

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**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25ppm(skin); OSHA PEL TWA 50 ppm (250mg/m<sup>3</sup>)(skin); NIOSH REL TWA 5ppm (24 mg/m<sup>3</sup>)(skin); IDLH 700 ppm.

**PERSONAL PROTECTION:** wear full protective clothing to prevent body contact with liquid; rubber gloves are recommended; wear safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; absorb as much as possible with materials such as dry earth, sand, or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and dispose of in a secured sanitary landfill; dissolve in a more flammable solvent and atomize in a suitable combustion chamber; store in a cool, dry location with adequate ventilation; keep away from heat, flame, and strong oxidizers.

**REGULATORY INFORMATION:** T120-a; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a solvent for nitrocellulose resins, spray lacquers, quick-drying lacquers, varnishes, enamels, varnish removers, and dry-cleaning compounds; mutual solvent for soluble mineral oils to hold soap in solution, and to improve emulsification; use to make acetate esters as well as phthalate and stearate plasticizers; preferred coupling agent for many water-based coatings.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 11.

### **BORON TRIFLUORIDE (BF<sub>3</sub>, 67.81)**

**CAS/DOT IDENTIFICATION #:** 7637-07-2/UN1008

**SYNONYMS:** boron fluoride, trifluoroborane

**PHYSICAL PROPERTIES :** colorless, compressed gas; pungent, suffocating odor; forms white fumes in moist air; soluble in cold water; soluble in concentrated sulfuric acid, fluoroboric and boric acids; soluble in most organic solvents, including alcohols, ethers, most saturated and halogenated hydrocarbons, and in aromatic compounds; MP (-127°C, -196.6°F); BP (-100°C, -148°F); DN(1.57 g/mL liquid at -100.4°C, 3.07666 g/L gas at STP); VS (17.0 μPa-s at 25°C); HV (19.33 kJ/mol at 172K); VD (2.38); VP (> 50 atm at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; polymerizes unsaturated molecules; hydrolyzes in moist air or hot water, forming boric acid, fluoroboric acid and hydrogen fluoride; easily forms coordination complexes (known as adducts) with molecules having at least one unshared electron pair (e.g., ethers), known as BF<sub>3</sub>-ether complex or boron trifluoride etherate; forms solid complex with nitric acid; FP (NA); LFL/UFL (NA); AT (NA); HF (-1136.0 kJ/mol gas at 25°C); H<sub>f</sub>(4.2 kJ/mol at 146.3K).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; does not support combustion; NFPA rating (not available); gas is heavier than air; attacks many metals in presence of water; reacts violently with alkali metals, alkaline earth metals (except magnesium), alkyl nitrate, and calcium oxide; will polymerize unsaturated compounds; very dangerous substance; decomposes when heated or upon contact with water or steam alkali metals, alkaline earth metals (except magnesium), alkyl nitrate, and calcium oxide; will polymerize unsaturated com-

pounds; very dangerous substance; decomposes when heated or upon contact with water or steam, producing toxic and corrosive fumes of hydrogen fluoride, fluoroboric acid and boric acid; use powder and carbon dioxide for firefighting purposes; in case of surrounding fire, all extinguishing agents are allowed.

**HEALTH SYMPTOMS:** inhalation (cough, burning sensation, labored breathing, lung edema, irritates eyes, skin and nose); skin contact (burning sensation, redness, pain, liquid may cause frostbite); eye contact (tear drawing, blurred vision, redness, pain).

**FIRST AID:** wash eyes with water for several minutes; promptly wash affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and provide oxygen; provide respiratory support if indicated.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** corrosive to eyes, skin and respiratory tract; may cause lung edema; epistaxis (nosebleed); nasals irritation; burn to eyes and skin; burred vision; tearing of eyes; cough; labored breathing; contact with liquid may cause frostbite.

**CHRONIC HEALTH RISKS:** may have effects on the kidneys; may cause pneumonia, as based on animal testing.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 1 ppm(2.8 mg/m<sup>3</sup>); OSHA PEL CL 1 ppm (3 mg/m<sup>3</sup>); NIOSH REL TWA 1 ppm (3 mg/m<sup>3</sup>); IDLH 25 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; a system of local exhaust ventilation is recommended; in high concentrations, wear self-contained breathing protection apparatus.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; use fine water spray to remove fumes; jet of water should never be directed on liquid.

**DISPOSAL AND STORAGE METHODS:** use water spray to cool and disperse fumes store in a cool, dry location; use only with adequate ventilation; fireproof if in building; separate from sodium, potassium, calcium alkyl nitrates, and lime.

**REGULATORY INFORMATION:** Sf2; Sf3; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas).

**OTHER COMMENTS:** largest application is as a catalyst in organic synthesis; used in the prediction of diborane (B<sub>2</sub>H<sub>6</sub>); used in ionization chambers for measuring neutron intensity; protects molten magnesium and its alloys from oxidation; other uses include soldering fluxes for magnesium, fumigation, and gas brazing.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

## **BROMINE (Br<sub>2</sub>, 159.82)**

**CAS/DOT IDENTIFICATION #:** 7726-95-6/1744

**SYNONYMS:** bromine solution, molecular bromine

**PHYSICAL PROPERTIES :** dark, reddish-brown, fuming liquid; reddish-brown vapor; rhombic crystals; diatomic liquid; heavier than water; suffocating, bleach odor; freely

soluble in alcohol, ether, chloroform, carbon disulfide, carbon tetrachloride, concentrated hydrochloric acid, and aqueous solution of bromides; soluble in water; miscible in most organic solvents; MP (-7.25°C, 19°F); BP (59.5°C, 139°F); DN (3.1023 g/mL at 25°C); LSG (3.12); ST (41.5 dynes/cm at 20°C); VS (0.99 cP at 19.5°C); CP (18.089 cal/mol-°C liquid at 25°C); HV (80.6 Btu/lb, 44.8 cal/g,  $1.88 \times 10^5$  J/kg); VD (5.5); VP (100 mmHg at 9.3°C, 175 mmHg at 20°C); OT (3.5 ppm).

**CHEMICAL PROPERTIES:** noncombustible liquid; volatile, fuming liquid; vaporizes rapidly at room temperature; corrodes iron, steel, stainless steel, and copper; strong oxidizer; reacts with alkalis and reducing agents; reacts strongly with reactive metals such as aluminum, potassium and sodium; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (0.0 kJ/mol liquid, 30.9 kJ/mol gas at 25°C);  $H_f$  (10.57 kJ/mol at 265.9K); DE (46.072 kcal at 25°C).

**EXPLOSION and FIRE CONCERNS:** not flammable; accelerates the burning of combustibles; NFPA rating Health 4, Flammability 0, Reactivity 1; flammable in liquid or vapor form by spontaneous chemical reaction with reducing agents; very powerful oxidizer; highly dangerous; reacts with water or steam to produce toxic and corrosive fumes; forms shock-sensitive mixtures with lithium; reacts vigorously with methanol, tetrahydrofuran, and mixtures of ethanol and phosphorus; explosive reactions with diethylzinc, disilane, dimethylformamide, hydrogen, antimony, ammonia, trimethylamine, and silver or sodium azide; ignites on contact with germanium, trialkyl boranes, and copper acetylides; violent reaction with aldehydes, ketones, carboxylic acids, diethyl ether, phosphine, natural rubber, mercury, aluminum, and titanium; incompatible with combustible organics (sawdust, wood, cotton, straw, etc.); use large amounts of water or use soda ash for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (severe irritation of the respiratory passages, pulmonary edema, coughing, difficult breathing, loss of consciousness); skin contact (acne, slow-healing ulcers, severe skin burns).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 14mg/kg; inhalation-human LCLo 1000ppm.

**ACUTE HEALTH RISKS:** irritation of the mucous membranes of the eyes and upper respiratory tract; dizziness; headache; coughing; lacrimation; nosebleed; pulmonary edema; abdominal pain; diarrhea; pneumonia; severe burns of eyes and skin.

**CHRONIC HEALTH RISKS:** depression; psychosis; mental deterioration; emaciation; bromoderma (rashes of the face resembling acne or measles-like eruptions).

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; ACGIH TLV STEL 0.2 ppm; OSHA PEL TWA 0.1 ppm (0.7 mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.7 mg/m<sup>3</sup>); NIOSH REL STEL 0.3 ppm (2 mg/m<sup>3</sup>); IDLH 3 ppm.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus and rubber-coated clothing; rubber gloves are recommended; wear chemical safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb large quantities of liquid in noncombustible materials such as vermiculite, dry earth, or sand; use soda ash to neutralize spilled liquid.

**DISPOSAL AND STORAGE METHODS:** cover liquid spills with lime water slurry or soda ash solution; absorb as much liquid as possible in dry earth or sand and place in a sanitary landfill; use anhydrous ammonia to neutralize vapors to ammonium bromide; route to sewage plant; store in a cool, dry location; separate from strong oxidizers, reducing agents, alkalies, and reactive metals.

**REGULATORY INFORMATION:** Sf2; Sf3; A1; A5; CAL; DOT hazard class/division (8); labels (corrosive, poison).

**OTHER COMMENTS:** used in water disinfection; used in bleaching fibers and silk; used in the manufacture of medicinal bromine compounds and manufacture of anti-knock compounds, such as ethylene bromide, for gasoline; chemical intermediate for ethyl bromide, methyl bromide, ethylene dibromide, and other bromine compounds; intermediate in manufacture of sedatives, anesthetics, antispasmodic agents, refrigerating and dehumidifying agents; use as a fire-retardant for plastics.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14.

### **BROMOFORM (CHBr<sub>3</sub>, 252.75)**

**CAS/DOT IDENTIFICATION #:** 75-25-2/UN2515

**SYNONYMS:** methyl tribromide, tribromomethane.

**PHYSICAL PROPERTIES :** colorless to pale-yellow liquid; chloroform-like odor; sweetish taste; soluble in benzene, chloroform, alcohol, ether, acetone, solvent naphtha, fixed and volatile oils; slightly soluble in water; MP (8.3°C, 47°F); BP(149°C, 300°F at 15mmHg); DN (2.8899 g/mL at 20°C): LSG (2.89); ST (41.53 dynes/cm at 20°C); HV (9,673.3 gcal/gmol); VD(8.7); VP (5mmHg at 20°C, 40mmHg at 63.6°C); OT (1.3 ppm).

**CHEMICAL PROPERTIES:** gradually decomposes, acquiring yellow color; air and light accelerate decomposition; attacks some forms of plastics, rubber, and coatings; reacts vigorously with metals, strong oxidizers, bases, acetone, lithium, and sodium-potassium alloy; solidifies at 7.5°C; HF (-59.4 kJ/mol liquid).

**EXPLOSION and FIRE CONCERNS:** nonflammable; NFPA rating (not rated); explosive reaction with crown ethers or potassium hydroxide; violent reaction with lithium, sodium-potassium alloy, acetone, or bases; incompatible with metals, caustic alkali, and strong oxidants; decomposition emits highly toxic gases and vapors (such as hydrogen bromide and bromine); use dry chemical, carbon dioxide, water spray, fog or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of nose and throat, provokes flow of tears and saliva); skin absorption (headaches, dizziness, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 143 mg/kg; sce-human lymphocyte 80µmol/L; EPA Cancer Risk Level (1 in a million excess lifetime risk)  $9 \times 10^{-4}$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory tract; dizziness; headache; convulsions; pulmonary edema; liver and kidney injury; central nervous system depression; shock; amnesia; death.

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**CHRONIC HEALTH RISKS:** liver and kidney damage; central nervous system depression; increase in liver and intestinal tumors in animals; EPA Group B2: probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (5mg/m<sup>3</sup>); OSHA PEL TWA 0.5 ppm (5mg/m<sup>3</sup>); NIOSH REL TWA 0.5 ppm (5mg/m<sup>3</sup>); IDLH 850 ppm.

**PERSONAL PROTECTION:** wear protective clothing, gloves, and face shields; wear splash proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; use water spray to "knock down" vapor; isolate and remove discharged material.

**DISPOSAL AND STORAGE METHODS:** product residues and sorbent media may be packaged appropriately and placed in a sanitary landfill; atomize large amounts by high temperature incineration with scrubbing equipment; use deep-well injection for disposal; store in tightly closed containers; storage should be in a cool, dry, well-ventilated area away from incompatible substances..

**REGULATORY INFORMATION :** CA2; S3; S40-e; R2-21; R3; R4; R5; R8; R9; U waste # (U225); Reportable Quantity (RQ): 100lbs (45.4kg); Sf1; Sf3; CW4; CW5; T30-e10; T799-5055; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used in the shipbuilding and aerospace industries; used in the chemical synthesis of pharmaceuticals, fire-resistant chemicals and gauge fluid; used as a catalyst in polymer reactions.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 12; 13; 14.

### 1,3-BUTADIENE (C<sub>4</sub>H<sub>6</sub>, 54.10)

**CAS/DOT IDENTIFICATION #:** 106-99-0/UN1010

**SYNONYMS:** biethylene, bivinyl, butadiene, divinyl, vinylethylene.

**PHYSICAL PROPERTIES :** colorless gas; mild aromatic or gasoline-like odor; soluble in organic solvents; soluble in ether and benzene; very soluble in acetone; slightly soluble in methanol and ethanol; sparingly soluble in water; MP (-109°C, -164°F); BP (-4.5°C, 24°F at 760mmHg); DN (0.621 l g/mL at 20°C); SG (0.621 at 20°C); ST (13.4 dynes/cm at 20°C); VS (0.00754 cP at 101.325 kPa, 20°C); HV (180 Btu/lb, 4.19 x 10<sup>5</sup> J/kg); VD (1.87); VP (910 mmHg at 20°C, 2100 mmHg at 25°C); OT (1.6 ppm).

**CHEMICAL PROPERTIES:** highly reactive; polymerizes and copolymerizes readily; dimerizes to 4-vinylcyclohexene; reacts vigorously with phenol, chlorine dioxide, copper and crotonaldehyde; stabilization with o-dihydroxybenzene; FP (-76°C, -105°F); LFL/UFL (2.0%, 11.5%); AT (420°C, 788°F).

**EXPLOSION and FIRE CONCERNS:** flammable gas; dangerous fire hazard; NFPA rating Health 2, Flammability 4, Reactivity 2; may form explosive peroxides upon exposure to air; autopolymerizes in the presence of sodium; forms carbon monoxide and carbon dioxide upon combustion; vapor may travel considerable distance to source of ignition and flash back; explodes on contact with aluminum tetrahydroborate; incompatible with strong oxidizers, halogens, oxygens, and copper alloys; use water as fog or spray, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); skin absorption (headaches, drowsiness, and nausea).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 2000ppm/7H: eye; inhalation-human 8000 ppm: eye, pul; EPA Cancer Risk Level (1 in a million excess lifetime risk)  $4.0 \times 10^6$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, throat, and lungs; headaches; drowsiness; blurred vision; vertigo; nausea; unconsciousness; frostbite.

**CHRONIC HEALTH RISKS:** cardiovascular diseases; respiratory paralysis; blood disorders; reproductive effects; EPA Group B2; probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2-10 ppm (4.4-22 mg/m<sup>3</sup>); OSHA PEL TWA 1000ppm (2210 mg/m<sup>3</sup>); NIOSH REL TWA reduce to lowest possible level; IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear a rubber suit, rubber boots, and thick rubber gloves; wear chemical-type safety goggles; wear self-contained breathing apparatus..

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; ventilate area and wash spill site; if in liquid form, absorb as much as possible on paper towels and evaporate in a fume hood; if in gaseous form, shut of leak; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** atomize large amounts in a suitable combustion chamber; cautiously ignite small amounts in open areas; outside storage is preferred; store in a cool, dry, well ventilated location; separate from oxidizing materials.

**REGULATORY INFORMATION :** CA2; R7; Sf3; A1; CAL; Reportable Quantity (RQ): 10lbs (4.54 kg); DOT hazard class/division (2.1); labels (flammable gas).

**OTHER COMMENTS:** used in the manufacture of synthetic rubber; usage in the formation of rocket fuels, plastics, and resins.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 12; 13; 14.

## **2-BUTANONE (C<sub>4</sub>H<sub>8</sub>O, 72.12)**

**CAS/DOT IDENTIFICATION #:** 78-93-3/UN1193

**SYNONYMS:** ethyl methyl ketone, MEK, methyl acetone, methyl ethyl ketone.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mint- or acetone-like odro; soluble in alcohol, ether, acetone, benzene, and water; MP (-86.3°C, -123.3°F); BP(79.6°C, 175.3°F); DN (0.80615 g/mL at 20°C); LSG(0.81 at 20°C); ST (24.6 dyne/cm at 20°C); VS (0.40 cP at 25°C); CP (0.5499 cal/g); HV (191 Btu/lb, 106 cal/g,  $4.44 \times 10^5$  J/kg); VP(77.5 mmHg at 20°C); OT (5.4ppm).

**CHEMICAL PROPERTIES:** generally stable; reacts vigorously with chloroform and alkali; vigorous reactions with strong oxidizers, amines, ammonia, inorganic acids, isocyanates, and pyridines; FP (-5.6°C, 22°F); LFL/UFL (1.4%, 11.4%); AT (515.6°C, 960°F); HC (-13,480 Btu/lb, -7491cal/g, -313.6 x 10<sup>5</sup> J/kg).

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**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; reacts with hydrogen peroxide and nitric acid to form a heat-and shock-sensitive explosive product; ignites on contact with potassium tert-butoxide; mixture with 2-propanol produces explosive peroxides during storage; incompatible with chlorosulfonic acid and oleum; flashback along vapor trail may occur; use alcohol foam, carbon dioxide, and dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes and skin); skin absorption (dizziness, nausea and vomiting).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** eye-human 350ppm; inhalation-human T<sub>CLo</sub> 100ppm.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and nose; irritating to mucous membranes and upper respiratory tract; central nervous system depression; dizziness; headache; vomiting; gastrointestinal effects; dermatitis.

**CHRONIC HEALTH RISKS:** effects on peripheral nervous system and central nervous system; respiratory system effect; liver damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200ppm; STEL 300ppm; OSHA PEL TWA 200ppm (590mg/m<sup>3</sup>); STEL 300ppm; NIOSH REL (ketones) TWA 200ppm (590mg/m<sup>3</sup>); STEL 300ppm (885mg/m<sup>3</sup>); IDLH 3000ppm.

**PERSONAL PROTECTION:** wear protective clothing and chemically resistant gloves; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use air stripping to provide removal at first-order kinetic rates; absorb as much as possible with materials such as dry earth or sand; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** dilute solutions and discharge directly into sewage treatment facilities; spray into incinerator or burn in paper packaging; storage should be away from heat, sparks, and open flames.

**REGULATORY INFORMATION :** R3; U waste # (U159); Reportable Quantity (RQ): 5000lbs (2270kg); Sfl; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the surface coating industry; used in the manufacture of synthetic resins, adhesives, cleaning fluids, and paint removers; used in pharmaceuticals and cosmetics.

**KEY REFERENCES:** 4; 5; 6; 7; 11; 12; 13; 14.

### 2-BUTOXYETHANOL (C<sub>6</sub>H<sub>14</sub>O<sub>2</sub>, 118.20)

**CAS/DOT IDENTIFICATION #:** 111-76-2/UN2369

**SYNONYMS:** butyl cellosolve®, butyl oxitol, downanol eb, egbe, etkasolve eb, ethylene glycol monobutyl ether, jeffersol eb.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mobile liquid; mild, ether-like odor; high dilution ratio with petroleum hydrocarbons; miscible in all proportions with many

ketones, ethers, alcohols, aromatic paraffins, and halogenated hydrocarbons; soluble in all proportions with acetone, benzene, ethyl ether, carbon tetrachloride, n-heptane, and water; MP (-70°C, -94°F); BP (171-172°C, 339.8-341.6°F); DN (0.912 g/mL at 20°C); LSG (0.90); ST (27.4 mN/m at 25°C); VS (2.83 centistokes at 25°C); HV (56.59 kJ/mol at 441.5K); VP (0.76 mmHg at 20°C, 300mmHg at 140°C).

**CHEMICAL PROPERTIES:** combustible; moderately volatile; 0.01 maximum percent acidity by weight; reacts with strong oxidizers and caustics; FP (61°C, 142°F); LFL/UFL (1.1% at 200°F, 12.7% at 275°F); AT (238°C, 460.4°F); HC (-13,890 Btu/lb, -7720 cal/g,  $-323 \times 10^5$  J/kg).

**EXPLOSION and FIRE CONCERNS:** combustible liquid when exposed to heat or flame; NFPA rating Health 2, Flammability 2, Reactivity 0; incompatible with oxidizing materials, heat and flame; heating to decomposition emits irritating fumes; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); ingestion or skin contact (headache, nausea, vomiting, dizziness); skin absorption (blood effects, central nervous system depression).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 195 ppm/8H; toxic effect: gastrointestinal tract; inhalation-human TCLo 100 ppm; toxic effect: nose, eye, central nervous system; oral-woman TDLo 600mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; headache; nausea; vomiting; dizziness; skin irritation; blood effects.

**CHRONIC HEALTH RISKS:** nose tumors; unspecified eye effects; central nervous system depression; hemolysis; hemoglobinuria; kidney and liver damage; injury to the lymphoid system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25ppm(skin); OSHA PEL TWA 50 ppm (250mg/m<sup>3</sup>)(skin); NIOSH REL TWA 5ppm (24 mg/m<sup>3</sup>)(skin); IDLH 700 ppm.

**PERSONAL PROTECTION:** wear full protective clothing to prevent body contact with liquid; rubber gloves are recommended; wear safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; absorb as much as possible with materials such as dry earth, sand, or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and dispose of in a secured sanitary landfill; dissolve in a more flammable solvent and atomize in a suitable combustion chamber; store in a cool, dry location with adequate ventilation; keep away from heat, flame, and strong oxidizers.

**REGULATORY INFORMATION:** T120-a; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a solvent for nitrocellulose resins, spray lacquers, quick-drying lacquers, varnishes, enamels, varnish removers, and dry-cleaning compounds; mutual solvent for soluble mineral oils to hold soap in solution, and to improve emulsification; used to make acetate esters as well as phthalate and stearate plasticizers; preferred coupling agent for many water-based coatings.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 11.

**n-BUTYL ACETATE (C<sub>6</sub>H<sub>12</sub>O<sub>2</sub>, 116.18)**

**CAS/DOT IDENTIFICATION #:** 123-86-4/UN1123

**SYNONYMS:** butyl acetate, 1-butyl acetate, n-butyl ester of acetic acid, butyl ethanoate.

**PHYSICAL PROPERTIES :** colorless liquid; strong fruity odor; pleasant, banana-like taste; miscible with alcohol, ether, and propylene glycol; soluble in ethanol, diethyl ketone and acetone; slightly soluble in water; vapor is heavier than air; MP (-77°C, -106.6°F); BP (125-126°C, 257-258°F); DN (0.8826 g/mL at 20°C); LSG (0.88); ST (14.5 dynes/cm at 25°C); VS (1.004 cP at 0°C, 0.732 cP at 20°C, 0.563 cP at 40°C); CP (227.8 J/K-mol liquid at 25°C); HV (133 Btu/lb, 73.9 cal/g, 3.09 x 10<sup>5</sup> J/kg); VP (15 mmHg at 25°C); OT (0.6 - 7 ppm).

**CHEMICAL PROPERTIES:** flammable liquid; heat contributes to instability; can react with nitrates, strong oxidizers, alkalis and acids; FP (22°C, 72°F); LFL/UFL (1.4%, 7.5%); AT (425°C, 797°F); HC (-13.130 Btu/lb, -7,294 cal/g, -305.4 x 10<sup>5</sup> J/kg); HF (-529.2 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; flashback along vapor trail may occur; vapor may explode if ignited in a confined area; moderately explosive when exposed to flame; ignites on contact with potassium tert-butoxide; incompatible with strong oxidizers, nitrates, alkalis, and acids, toxic gases and vapors, such as carbon monoxide, may be released in a fire; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headaches, dizziness, nausea, irritation of respiratory passages and eyes, difficulty breathing); contact (irritates skin and eyes, may lead to drying of skin).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** eye-human 300 ppm; inhalation-human TCl<sub>o</sub> 200 ppm; toxic effect: nose, eye, pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory system; drowsiness; headaches; dizziness; nausea; conjunctiva irritation; unspecified nasal and respiratory system effects; narcosis; difficult breathing.

**CHRONIC HEALTH RISKS:** evidence of chronic systemic toxicity is inconclusive; chronic allergen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 150 ppm; ACGIH TLV STEL 200ppm; OSHA PEL TWA 150 ppm (710 mg/m<sup>3</sup>); NIOSH REL TWA 150 ppm (710mg/m<sup>3</sup>); NIOSH REL STEL 200 ppm (950 mg/m<sup>3</sup>); IDLH 1700 ppm.

**PERSONAL PROTECTION:** wear protective outerwear (boots, gloves, sleeves, aprons, etc.); wear splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in fume hood; atomize large quantities in a suitable combustion chamber; absorb as much as possible with materials such as dry earth or sand and place in a secured sanitary landfill; flush remaining n-butyl acetate with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** spray into incinerator or burn in paper packaging; dissolve in additional flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers, alkalies, and acids.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 5000 lbs. (2270 kg); T799-5000; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of lacquer, artificial leather, photographic films, plastics, and safety glass; solvent for nitrocellulose, oils, fats, waxes, camphor, cellulose esters, fingernail polishes, resins, and lacquer stains; synthetic flavoring ingredient used in producing banana, pear, pineapple and berry flavors.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 11; 12; 14.

### **SEC-BUTYL ACETATE** ( $\text{CH}_3\text{COOCH}(\text{CH}_3)\text{CH}_2\text{CH}_3$ , 116.18)

**CAS/DOT IDENTIFICATION #:** 105-46-4/UN1123

**SYNONYMS:** acetic acid-1-methylpropyl ester, 2-butanol acetate, sec-butyl ester of acetic acid, 1-methylpropyl acetate.

**PHYSICAL PROPERTIES :** colorless liquid; has a pleasant, fruity odor characteristic of acetate esters; miscible with alcohol and ether; poor solubility in water; soluble in acetone; FRZP (-73.5°C, -100°F); BP (112°C, 234°F); DN (0.862-0.866 g/mL at 20°C); LSG (0.86-0.87 at 20°C); ST (23.3 dynes/cm at 21°C); HV (130 Btu/lb, 74 cal/g,  $3.1 \times 10^5$  J/kg); VD (4.00); VP (10 mmHg at 20°C, 24 mmHg at 25°C); RELDN of vapor/air mixture (1.04 at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; heat contributes to instability; hazardous polymerization will not occur; reacts vigorously with strong oxidizers; FP (17°C, 63°F); LFL/UFL (1.7%, 9.8%); AT (NA); HC (-13,100 Btu/lb, -7,300 cal/g,  $-305 \times 10^5$  J/kg).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; dangerous fire risk; NFPA rating Health 1, Flammability 3, Reactivity 0; vapor mixes well with air, forming explosive vapor/air mixtures; flashback along vapor trail may occur; vapor may explode if ignited in an enclosed area; reacts with strong oxidants, strong bases, strong acids and nitrates, causing fire and explosion hazard; heating to decomposition may emit toxic fumes of carbon dioxide and carbon monoxide; use alcohol-resistant foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, headache, difficult breathing, cough, sore throat lowering of consciousness, irritates eyes and upper respiratory tract); skin contact (dry skin, may cause defatting of skin); eye contact (can cause conjunctivitis).

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**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, rinse mouth and get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes; dryness of upper respiratory system and skin; headache; dizziness; drowsiness; narcosis; cough; sore throat; nausea; lowering of consciousness.

**CHRONIC HEALTH RISKS:** liquid defats the skin; targets eyes, skin, respiratory system and central nervous system, potential as chronic allergen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm (950 mg/m<sup>3</sup>); OSHA PEL TWA 200 ppm (950 mg/m<sup>3</sup>); NIOSH REL TWA 200 ppm (950 mg/m<sup>3</sup>); IDLH 1700 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear chemical safety goggles or face splash shield; a system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; use explosion-proof electrical equipment and lighting; compressed air should not be used for filling, discharging, or handling; use self-contained breathing apparatus in oxygen deficient atmospheres; an air filter for organic vapors may be used for extra personal protection..

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers; absorb remaining liquid in vermiculite, dry earth, or sand, and remove to a safe place; flush remaining amounts with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent and place in a secured sanitary landfill; atomize large quantities in a suitable combustion chamber; store in a cool, dry location; maintain adequate ventilation; fireproof if in building; separate from strong oxidants, strong bases, strong acids, and nitrates.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 5000 lbs (2270 kg); Sfl; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose lacquers, thinners, nail enamels, and leather finishes.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 14.

**TERT-BUTYL ACETATE** (CH<sub>3</sub>COOC(CH<sub>3</sub>)<sub>3</sub>, 116.18)

**CAS/DOT IDENTIFICATION #:** 540-88-5/UN1123

**SYNONYMS:** acetic acid tert-butyl ester, ethanoic acid tert-butyl ester, tert-butyl ester of acetic acid, tert-butyl ethanoate.

**PHYSICAL PROPERTIES :** colorless liquid; fruity, pleasant odor; soluble in alcohol, ether and acetic acid; practically insoluble in water; MP (unknown); BP (98°C, 208°F); DN (0.8665 g/mL at 20°C); LSG (0.87); VD (unknown); BP (unknown).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; sensitive to heat; hazardous polymerization will not occur; materials to avoid include strong oxidizing agents, strong acids, strong bases, and nitrates; FP (22°C, 72°F); LFL/UFL (1.5%, unknown); AT (NA).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 0; volatile vapors may travel considerable distance to source of ignition and flashback; vapor may explode if ignited in a confined area; incompatible with nitrates, strong oxidizers, strong alkalies and acids; decomposition liberates toxic fumes; hazardous combustion or decomposition products include carbon monoxide and carbon dioxide; use carbon dioxide, dry chemical powder, and alcohol-resistant foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract and mucous membranes, slow and gradual onset of narcosis, tendency to headache, pain in chest, difficult breathing); eye contact (itching, tearing, inflammation); skin contact (allergic skin reaction, skin sensitization); ingestion (headache, nausea, dizziness, fatigue).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; if not breathing, administer artificial respiration; administer CPR if in cardiac arrest; if ingested, do not induce vomiting; contact poison control center immediately if necessary.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of upper respiratory tract (i.e., nose and throat); itching and inflammation of eyes; headache; coughing; shortness of breath; pain in chest; nausea; dizziness; slight allergen; narcosis.

**CHRONIC HEALTH RISKS:** severe headache; general disorientation; can cause allergic skin reaction; can cause skin sensitization; can also cause eye injury.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm; OSHA PEL TWA 200 ppm (950 mg/m<sup>3</sup>); NIOSH REL TWA 200 ppm (950 mg/m<sup>3</sup>); IDLH 1500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear chemical safety goggles in combination with breathing protection; use self-contained breathing apparatus in high vapor concentrations; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; absorb as much as possible with non-combustible materials (e.g., dry earth, sand, vermiculite); sweep up and place in an appropriate chemical waste container; wash contaminated surfaces to remove any residues.

**DISPOSAL AND STORAGE METHODS:** absorb with sand or other inert materials, and place in impervious containers; burn in a chemical incinerator equipped with an afterburner and scrubber; materials may also be burned in a chemical waste landfill if appropriate incineration facilities are not available; disposal must be in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; keep in tightly closed containers; store only with compatible chemicals.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 5000 lbs (2270kg); Sfl; T30-e10; T120-d10; A1; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as an antiknock action enhancer of tetraethyl lead, especially at very high octane levels; useful as a gasoline additive and solvent.

**KEY REFERENCES:** 3; 4; 5; 6; 7.

**n-BUTYL ALCOHOL (CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH, 74.14)**

**CAS/DOT IDENTIFICATION #:** 71-36-3/UN1120

**SYNONYMS:** 2-butanol, butan-1-ol, n-butanol, butyl alcohol, butyl hydroxide, 1-hydroxybutane, propylcarbinol, propylmethanol.

**PHYSICAL PROPERTIES :** colorless liquid; strong, mildly alcoholic odor; dry, burning taste; miscible with alcohol, ether and many organic solvents; moderately soluble in water; MP (-89.5°C, -129°F); BP (117.2°C, 243°F); DN (0.8098 g/mL at 20°C); LSG (0.81); ST (22.25 dynes/cm at 30°C); VS (5.186 cP at 0°C, 2.948 cP at 20°C, 0.540 cP at 100°C); CP (177.2 J/K-mol liquid at 25°C); HV (52.35 kJ/mol at 25°C); VD (2.55); VP (5.5 mmHg at 20°C); OT (7.1 mg/L water, 0.83 ppm air).

**CHEMICAL PROPERTIES:** highly refractive liquid; burns with a strongly luminous flame; leaves a transitory greasy spot on paper; degrades rapidly; attacks some forms of plastics, rubber and coatings; FP (35-37.8°C, 95-100°F); LFL/UFL (1.4%, 11.2%); AT (406°C, 763°F); HC (639.53 kcal/gmol at 25°C); HF (-327.3 kJ/mol liquid at 25°C); H<sub>f</sub> (9.28 kJ/mol at 183.3K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 0; moderately explosive when exposed to flame; flashback along vapor trail may occur; vapor may be explosive if ignited in a confined area; volatile liquid; incompatible with aluminum, chromium trioxide, oxidizing materials, strong mineral acids, alkali metals, and halogens; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use water spray, carbon dioxide, dry chemical, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, nasal effects, nausea, headache, dizziness, irritation of respiratory passages, anesthesia); contact (dermatitis about fingernails and along side of fingers, irritates eyes, nose and throat).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 25 ppm; toxic effect: irritant effect on the skin, eye, or mucous membranes; eye-human 50 ppm.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; vertigo; drowsiness; blurred vision; corneal inflammation; lacrimation; nasal effects; unspecified respiratory system effects; headache; dizziness; abnormal visual intolerance to light.

**CHRONIC HEALTH RISKS:** auditory nerve damage; hearing loss; central nervous system depression; dermatitis about the fingernails and along the side of the fingers; may alter genetic material.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 50 ppm(skin); OSHA PEL TWA 100 ppm (300 mg/m<sup>3</sup>); NIOSH REL CL 50 ppm (150mg/m<sup>3</sup>)(skin); IDLH 1400 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and face shields; wear splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; absorb as much as possible with noncombustible materials such as dry earth or sand, and place in a secured sanitary landfill; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** spray into incinerator or burn in paper packaging; dissolve in additional flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers, strong mineral acids, alkali metals, and halogens.

**REGULATORY INFORMATION:** S10; U waste #(U031); Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sfl; Sf3; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for fats, waxes, resins, shellac, varnish, gums, etc.; used in the preparation of esters, especially butyl acetate; used in the manufacture of hydraulic fluids and detergent formulations; also used as an azeotropic dehydrating agent; chemical intermediate for butylamines, glycol ethers, and butyl acrylate; used as an extractant in the manufacture of antibiotics, vitamins, and hormones.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 11; 12.

## **SEC-BUTYL ALCOHOL (CH<sub>3</sub>CHOHCH<sub>2</sub>CH<sub>3</sub>, 74.14)**

**CAS/DOT IDENTIFICATION #:** 78-92-2/UN1120

**SYNONYMS:** 2-butanol, 2-butyl alcohol, butylene hydrate, 2-hydroxybutane, methyl ethyl carbinol, 1-methyl propanol.

**PHYSICAL PROPERTIES :** clear, colorless liquid; strong, pleasant odor; miscible with alcohol and ether; soluble in 12 parts water (i.e., moderately soluble in water); MP (-115°C, -175°F); BP (99.5°C, 211°F); DN (0.808 g/mL at 20°C); LSG (0.81); ST (22.54 mN/m at 25°C); VS (3.096 mPa-s at 25°C); CP (196.9 J/K-mol liquid at 25°C); HV (49.72 kJ/mol at 25°C); VD (2.6); VP (13 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with strong oxidants, such as chromium trioxide; attacks some plastics and rubber; FP (24°C, 75°F); LFL/UFL (1.7%, 9.8%); AT (405°C, 761°F); HC (-2.4408 x 10<sup>9</sup> J/kmol); HF (-342.6 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; NFPA rating Health 1, Flammability 3, Reactivity 0; explosive vapor/air mixtures may be formed above 24°C; sensitive to static discharge; auto-oxidizes to form explosive peroxides; reacts with aluminum forming flammable gas; reaction with strong oxidants, such as chromium trioxide, will cause a fire hazard; incompatible with acids, acid chlorides, acid anhydrides, organic peroxides, chromium trioxide, oxidizing agents, and halogens; carbon dioxide and carbon monoxide may form when heated to decomposition; use foam, powder, alcohol-resistant foam, water spray or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, drowsiness, sore throat, cough, irritates respiratory tract); skin contact (mild irritation, dry skin, dermatitis, may cause allergic

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reaction); eye contact (redness, pain, blurred vision); ingestion (sore throat, headache, dizziness, drowsiness).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, rinse mouth and drink large amounts of water.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to the respiratory tract; sore throat; cough; headache; dizziness; drowsiness; mild skin irritation; eye irritation with redness and pain; blurred vision; may cause effects on the central nervous system; lowering of consciousness.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact with skin may cause dermatitis; persons with pre-existing impairment of liver, kidney, or pulmonary function may have a greater susceptibility to the effects of this agent.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm (303 mg/m<sup>3</sup>); OSHA PEL TWA 150 ppm (450 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (305 mg/m<sup>3</sup>); NIOSH REL STEL 150 ppm (455 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles where splashing is possible; above 24°C, use a closed system of local exhaust ventilation and explosion-proof electrical equipment; use a full-facepiece, positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking liquid in sealable containers; absorb remaining liquid in sealable containers; absorb remaining liquid with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush remainder with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent and place in a sanitary landfill; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry location; maintain adequate ventilation; outside storage is preferred; containers should be bonded and grounded for transfers to avoid static sparks; use non-sparking type tools and equipment, including explosion proof ventilation; keep away from any area where the fire hazard may be acute; separate from aluminum and strong oxidants.

**REGULATORY INFORMATION:** Sf3; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the preparation of methyl ethyl ketone; useful as a solvent for many natural resins, linseed and castor oils; has also been used in the synthesis of perfumes, dyestuffs, flavors, flotation and wetting agents; use in paint removers and industrial cleaners.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

**TERT-BUTYL ALCOHOL ((CH<sub>3</sub>)<sub>3</sub>COH, 74.14)**

**CAS/DOT IDENTIFICATION #:** 75-65-0/UN1120

**SYNONYMS:** 2-methyl-2-propanol, tert-butanol, tert-butyl hydroxide, trimethyl carbinol.

**PHYSICAL PROPERTIES :** colorless liquid; colorless, hygroscopic crystals below melting point (79°F); camphor-like odor; miscible with water, alcohol, and ether; vapor mixes well with air; often used in aqueous solutions; MP (26°C, 79°F); BP (82°C, 180°F); DN (0.781 g/mL liquid at 25°C); SG (0.79 (solid)); VS (4.31 mPa-s at 25°C); CP (218.6 J/K-mol liquid at 25°C); HV (46.69 kJ/mol at 25°C); VD (2.6); VP (42 mmHg at 77°F); RELDN vapor/air mixture (1.06 at 20°C).

**CHEMICAL PROPERTIES:** stable at room temperature in sealed containers; hazardous polymerization will not occur; may attack some forms of plastics and rubber; reacts with hydrochloric acid to form tert-butyl chloride; FP (11°C, 52°F); LFL/UFL (2.4%, 8.0%); AT (478°C, 892°F); HC (-2.4239 x 10<sup>9</sup> J/kmol); HF (-359.2 kJ/mol liquid at 25°C); H<sub>f</sub> (6.79 kJ/mol at 298.5K).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid and vapor; NFPA rating Health 1, Flammability 3, Reactivity 0; above flash point, vapor-air mixtures are explosive within flammable limits; flashback along vapor trail may occur; sensitive to static discharge; decomposes on contact with strong mineral acids producing flammable isobutylene gas; ignites on contact with potassium-sodium alloys; incompatible with strong oxidizing agents, hydrogen peroxide and sulfuric acid, mineral acids and alkali metals; heating to decomposition may emit carbon monoxide, carbon dioxide and isobutylene; use dry chemical, alcohol-resistant foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract, difficult breathing, coughing, headache, dizziness, drowsiness, narcosis); skin contact (irritation with redness and pain, dermatitis); eye contact (irritation, redness, pain, blurred vision); ingestion (abdominal pain, vomiting, diarrhea, headache, dullness, confusion, delirium, giddiness, muscle weakness, damage to the liver, kidney damage, pulmonary and cardiac damage).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, rinse mouth and drink large amounts of water.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to upper respiratory tract; headache; dizziness; drowsiness; difficult breathing; coughing; abdominal pain; vomiting; diarrhea; narcosis; dullness; giddiness; confusion; delirium; muscle weakness; ataxia; may cause liver, kidney, pulmonary and cardiac damage; coma; death from respiratory failure.

**CHRONIC HEALTH RISKS:** may cause dermatitis, kidney and liver effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm (303 mg/m<sup>3</sup>); OSHA PEL TWA 100 ppm (300 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (300 mg/m<sup>3</sup>); NIOSH REL STEL 150 ppm (450 mg/m<sup>3</sup>); IDLH 1600 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles where splashing is possible; above 24°C, use a closed system of local exhaust ventilation and explosion-proof electrical equipment; use a full-facepiece, positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking liquid in sealable containers; absorb remaining liquid in sealable containers; absorb remaining liquid with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush remainder with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent and place in a sanitary landfill; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry location; maintain adequate ventilation; outside storage is preferred; containers should be bonded and grounded for transfers to avoid static sparks; use non-sparking type tools and equipment, including explosion proof ventilation; keep away from any area where the fire hazard may be acute; separate from strong acids, strong oxidizing agents, peroxides, and alkali metals.

**REGULATORY INFORMATION:** Sf3; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a denaturant for ethanol; used in the manufacture of flotation agents, flavors, perfumes, dehydration agents, and paint removers; also used as a solvent for pharmaceuticals and in the manufacture of methyl methacrylate; useful as an octane booster in unleaded gasoline (EPA approved).

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### **BUTYLAMINE (CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>, 73.16)**

**CAS/DOT IDENTIFICATION #:** 109-73-9/UN1125

**SYNONYMS:** 1-aminobutane, 1-butanamine, n-butylamine, monobutylamine.

**PHYSICAL PROPERTIES :** clear, colorless liquid; fishy, ammonia-like odor; miscible with water, alcohol, and ether; MP (-49°C, -56°F); BP (78°C, 172°F); DN (0.74 - 0.76 g/mL at 20°C); LSG (0.74); ST (23.44 mN/m at 25°C); VS (0.574 mPa-s at 25°C); CP (179.2 J/K-mol liquid at 25°C); HV (35.72 kJ/mol at 25°C); VD (2.5); VP (82 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary condition of use and storage; hazardous polymerization will not occur; reacts with strong acids, oxidizing materials, chlorine, hypochlorite, halogenated compounds, and reactive organic compounds; liberates ammonia vapor upon decomposition; FP (-12°C, 10°F); LFL/UFL (1.7%, 9.8%); AT (312°C, 594°F); HF (-127.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** extremely flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; dangerous fire hazard when exposed to heat, flame, or oxidizers; flashback along vapor trail may occur; vapor-air mixtures are explosive within flammable limits above flash-point; sensitive to static discharge; closed containers exposed to heat may explode; contact with strong oxidizers may cause fire; explodes on contact with perchloryl fluoride; may corrode some metals in presence of water; not compatible with oxidizing agents, perchloryl fluoride, and strong acids; heating to decomposition may produce carbon monoxide, carbon dioxide, and oxides of nitrogen; use water spray, alcohol foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, coughing, chest pains, pulmonary edema, nausea, vomiting, faintness, convulsions, narcosis, loss of consciousness, depression); skin contact (deep penetrating burns, symptoms parallel those from inhalation); eye con-

tact (burns, severe damage, loss of vision); ingestion (irritates mouth, throat, and gastrointestinal tract).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; immediately flush affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if ingested, give large quantities of water; do not induce vomiting

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of nose and throat; headache; dizziness; pulmonary edema; nausea; vomiting; faintness; coughing; chest pains; depression; convulsions; narcosis; loss of consciousness; severe eye damage; skin flushing and burns.

**CHRONIC HEALTH RISKS:** prolonged or repeated skin exposure may cause dermatitis; persons with pre-existing skin disorders or eye problems or impairment of respiratory function may be more susceptible to the effects of this substance.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm(skin); OSHA PEL CL 5 ppm (15mg/m<sup>3</sup>)(skin); NIOSH REL CL 5 ppm (15 mg/m<sup>3</sup>)(skin); IDLH 300 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; use splash-proof safety goggles and/or full face shield where splashing is possible; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); in high vapor concentrations, wear positive pressure self-contained breathing apparatus; use non-sparking type tools and equipment, including explosion proof ventilation; maintain eye wash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; use water spray to cool and reduce vapors, and dilute spills to form nonflammable mixtures; collect liquid in an appropriate container or absorb with noncombustible materials (e.g., sand, clay, dry earth), and place in a chemical waste container; flush remaining liquid with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb with an inert material (e.g., dry sand, earth, vermiculite), and place in a secured, sanitary landfill or in a chemical waste container; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry location with adequate ventilation; outside storage is preferred; containers should be bonded and grounded for transfers to avoid static sparks; separate from oxidizing materials, acids, and sources of halogens; keep away from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 1000 lbs. (454 kg); Sf1; CW1; CW2; A1; CAL; DOT hazard class/division (3); labels (flammable liquid, corrosive).

**OTHER COMMENTS:** used as an intermediate for pharmaceuticals, emulsifying agents, rubber chemicals, dyes, tanning agents, and insecticides.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 14.

**TERT-BUTYL CHROMATE (C<sub>8</sub>H<sub>18</sub>CrO<sub>4</sub>, 230.26)**

**CAS/DOT IDENTIFICATION #:** 1189-85-1/none

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**SYNONYMS:** bis (tert-butyl) chromate, chromic acid bis (1,1-dimethylethyl) ester, di-tert-butyl ester of chromic acid, t-butyl chromate.

**PHYSICAL PROPERTIES :** clear, colorless liquid; solidifies at 32-23°F (0 to 5°C); degree of water solubility has not been reported in the literature; MP (-5 to 0°C, 23-32°F); BP (unknown); DN (unknown); SG (unknown); VP (unknown).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react with strong bases, strong acids, alcohols, hydrazine, and combustible, organic or other easily oxidized materials; FP (unknown); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** a very flammable mixture and fire hazard; NFPA rating (not rated); poisonous gases are produced in fire; reacts violently with strong bases (such as sodium hydroxide and potassium hydroxide), strong acids (such as hydrochloric, sulfuric and nitric), alcohols, and hydrazine; incompatible with combustible materials (such as paper, wood, sulfur, aluminum and plastics); hazardous decomposition products include carbon monoxide and carbon dioxide; use dry chemical, water spray, sand or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates nose and throat, coughing, wheezing, shortness of breath, chest tightness); contact (burns, blisters, deep ulcers, severe eye damage); ingestion (headache, nausea, vomiting, diarrhea).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with large amounts of soap and water; if breathing is difficult, give oxygen; if breathing has stopped, perform artificial respiration; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no toxicity data has been reported in the literature.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; severe eye and skin burns; irritation to nose and throat; coughing; wheezing; drowsiness; muscle weakness; lung changes; headache; nausea; vomiting; diarrhea.

**CHRONIC HEALTH RISKS:** can cause a hole in the bone (or septum) dividing the inner nose, resulting in discharge, bleeding and/or formation of a crust; may cause a skin allergy; may cause an asthma-like allergy, with asthma attacks, shortness of breath, wheezing, cough, and chest tightness; prolonged skin contact can cause burns, blisters and deep ulcers; has not been identified as a carcinogen, though Chromium VI compounds have been reported to be human carcinogens.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 0.1 mg(CrO<sub>3</sub>)/m<sup>3</sup>(skin); OSHA PEL CL 0.1 mg (CrO<sub>3</sub>)/m<sup>3</sup>(skin); NIOSH REL TWA 0.001 mg Cr(VI)/m<sup>3</sup>/10H; IDLH 15 mg Cr(VI)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-resistant goggles when working with liquids; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use non-sparking type tools and equipment when opening and closing containers of tert-butyl chromate; for increased protection, use self-contained breathing apparatus; maintain eyewash bath and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb liquids with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush re-

maining spill with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; use only with adequate ventilation; metal containers should be grounded and bonded during transfer; avoid contact with moisture, strong bases, strong acids, alcohols, and combustible materials; isolate from sources of ignition, such as smoking and open flames.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used in specialty chemical reactions as an organic source of chromium; also used in the preparation of catalysts; useful as a curing agent for urethane foams.

**KEY REFERENCES:** 4; 5; 6; 7; 15.

### **n-BUTYL GLYCIDYL ETHER (C<sub>7</sub>H<sub>14</sub>O<sub>2</sub>, 130.21)**

**CAS/DOT IDENTIFICATION #:** 2426-08-6/none

**SYNONYMS:** bge, 1-butoxy-2,3-epoxypropane, 3-butoxy-1,2-epoxypropane, butyl-2,3-epoxypropyl ether, butyl glycidyl ether, 1,2-epoxy-3-butoxypropane, 2,3-epoxypropyl butyl ether.

**PHYSICAL PROPERTIES :** clear, colorless liquid; irritating odor; 2% solubility in water at 20°C; MP (unknown); BP (164°C, 327°F); DN (0.908 g/mL at 25°C); LSG (0.91); VD (3.78 at 25°C); VP (3.2 mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react vigorously with oxidizing agents, strong acids, and strong bases; FP (55°C, 131°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible liquid, NFPA rating (not rated); may form explosive peroxides when exposed to air and light; incompatible with oxidizing agents (such as peroxides, permanganates, perchlorates, nitrates, chlorates, chlorine, bromine and fluorine), strong bases (such as sodium hydroxide and potassium hydroxide), strong acids (such as hydrochloric, sulfuric and nitric), and moisture; poisonous gases are produced in a fire, including carbon monoxide; use dry chemical, water spray, carbon dioxide, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, lightheadedness, dizziness, incoordination, fainting, coughing, wheezing, irritates eyes, nose and throat); contact (central nervous system depression, sensitization of skin, skin allergies); ingestion (possible hematopoietic effects, headache, lightheadedness, other symptoms parallel those of inhalation).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, move exposed person to fresh air and provide oxygen; if breathing has stopped, perform mouth-to-mouth resuscitation; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans; glycidyl n-butyl ether, dissolved in dimethyl sulfoxide (DMSO), was tested at concentrations of 0, 1, 10, 100, 500, or 1000 ppm using an incubation period of 5 hrs, in order to evaluate unscheduled DNA

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synthesis in human mononucleated cells; the results showed increased DNA synthesis of cells treated with 10 or 100 ppm; GBE at 500 ppm was nearly completely toxic to the cell cultures; for the tests of GBE at 1000 ppm, no results were reported.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; irritation of nose and throat, causing coughing and wheezing; can cause headache, lightheadedness, dizziness, incoordination and fainting; depression of central nervous system; irritation of surface tissues; paralysis of respiratory center; acute pulmonary edema; high concentrations may cause unconsciousness and death.

**CHRONIC HEALTH RISKS:** can cause inflammation and sensitization for skin; may cause a skin allergy; limited evidence has shown that n-butyl glycidyl ether causes mutations.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm (133 mg/m<sup>3</sup>); OSHA PEL TWA 50 ppm (270 mg/m<sup>3</sup>); NIOSH REL CL 5.6 ppm (30 mg/m<sup>3</sup>); IDLH 250 ppm.

**PERSONAL PROTECTION:** wear appropriate personal protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles when working with liquids; a closed system of local exhaust ventilation should be provided at the site of release; appropriate respirators are needed in areas where the potential exists for exposure over 5.6 ppm; if the possibility of exposure above 250 ppm exists, use self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb liquids with noncombustible materials (e.g., dry earth, sand, vermiculite), and deposit in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; may be disposed of in accordance with federal, state, and local regulations; store in a cool, well-ventilated area away from air and light as explosive peroxides may form; store in tightly closed containers; separate from strong oxidizers, strong acids, and strong bases; avoid sources of ignition, such as heat and open flames; avoid sources of moisture.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a reactive diluent for epoxy resins; also used as a viscosity-reducing agent for easier handling of conventional epoxy resins; useful in stabilizing chlorinated solvents by acting as an acid acceptor; applications as an intermediate in many chemical reactions.

**KEY REFERENCES:** 4; 5; 6; 7; 14; 15.

### **BUTYL MERCAPTAN (CH<sub>3</sub>(CH<sub>2</sub>)<sub>3</sub>SH, 90.20)**

**CAS/DOT IDENTIFICATION #:** 109-79-5/UN2347

**SYNONYMS:** butanethiol, 1-butanthiol, n-butanethiol, n-butyl mercaptan, 1-mercaptobutane, thiobutyl alcohol.

**PHYSICAL PROPERTIES :** colorless to yellow liquid; mobile liquid; strong, obnoxious skunk-like odor; very soluble in alcohol, ether, and liquid hydrogen sulfide; slight solubility in water; forms azeotropic mixtures with butyl alcohol (85.16% butanethiol, BP 97.8°C) and with butyl alcohol and water; MP (-116°C, -177°F); BP (98°C, 208°F); DN (0.8365 g/mL at

25°C); LSG (0.83); CP (171.2 J/K-mol liquid at 25°C); HV (36.63 kJ/mol at 25°C); VD (3.1); RELDN of vapor/air mixture (1.2 at 20°C); VP (35 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with acids, bases, alkali metals, and strong oxidants (such as dry bleaches); FP (2°C, 35.6°F); LFL/UFL (unknown); AT (<225°C, <437°F); H F(-124.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; dangerous fire risk when exposed to heat, flame, sparks, or powerful oxidizing agents; vapor/air mixtures are explosive; flashback along vapor trail may occur; violent reaction with nitric acid; incompatible with acids, acid fume, and strong oxidizers; decomposes on burning or heating, producing highly toxic fumes of oxides of sulfur; use alcohol-resistant foam, powder or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (weakness, confusion, cough, headache, dizziness, nausea, vomiting, shortness of breath); skin/eye contact (redness, pain); ingestion (symptoms parallel those of inhalation).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if swallowed, rinse mouth and get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; cough; shortness of breath; dizziness; headache; weakness; confusion; nausea; vomiting; pulmonary irritation; muscle weakness; malaise (vague feeling of discomfort); effects on central nervous system; lowering of consciousness; effects on the thyroid.

**CHRONIC HEALTH RISKS:** kidney damage; injury to the liver; targets eyes, skin, respiratory system, central nervous system, liver, and kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (1.8 mg/m<sup>3</sup>); OSHA PEL TWA 10 ppm (35 mg/m<sup>3</sup>); NIOSH REL CL 0.5 ppm (1.8 mg/m<sup>3</sup>)[15-min]; IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles or eye protection in combination with breathing protection; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; wear self-contained breathing apparatus if the exposure limit is exceeded; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** evacuate danger area; collect spilled liquid in sealable containers as far as possible; absorb remaining liquid in sand or other inert absorbents, and place in a chemical waste container; use water spray to cool and disperse vapors, and flush spills away from exposures; do not wash away into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** manage whatever cannot be saved for recovery or recycling in an appropriate and approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; outside storage is preferred; inside storage should be in a standard flammable liquid storage room or cabinet; use explosion-proof electrical equipment and lighting;

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do not use compressed air for filling, discharging, or handling; keep away from any area where the fire hazard may be acute; separate from strong oxidants, acids, bases, and alkali metals.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** useful as a chemical intermediate; has also been used as a solvent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **p-tert-BUTYLTOLUENE ((CH<sub>3</sub>)<sub>3</sub>CC<sub>6</sub>H<sub>4</sub>CH<sub>3</sub>, 148.27)**

**CAS/DOT IDENTIFICATION #:** 98-51-1/UN2667

**SYNONYMS:** benzene, 1-methyl-4-(1,1-dimethylethyl)-(9CI), 4-tert-butyltoluene, p-methyl-tert-butylbenzene, 1-methyl-4-tert-butylbenzene, tbt.

**PHYSICAL PROPERTIES :** clear, colorless liquid; aromatic, gasoline-like odor; soluble in acetone and benzene; very soluble in ether and chloroform; slightly soluble in alcohol; not soluble in water; MP (-52°C, -61.6°F); BP (189-192°C, 372.2-377.6°F); DN(0.8612 g/mL at 20°C); LSG (0.86); VD (4.62); VP (0.65 mmHg at 25°C); SADTLER REF NUMBER: 8311 (IR, PRISM), 2215 (UV), 596 (NMR, VARIAN); IR (2:504 Å); OT (30 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; incompatible with oxidizing materials; no reaction with water; FP (68.3°C, 155°F); LFL/UFL (unknown); AT (data not available); HC (data not available).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; flammable; moderately dangerous fire risk; NFPA rating (data not available); hazardous reaction with oxidizing materials; hazardous combustion products include carbon monoxide and carbon dioxide; use water spray, carbon dioxide, dry chemical or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, nausea, vomiting, dizziness, decreased respiratory effort, nasal irritation, throat irritation, unspecified effects on the sense of taste); skin absorption (tremors, decreased blood pressure, increased pulse rate, anxiety, chemical contact irritation of respiratory tract); ingestion (nausea, vomiting, lowered hemoglobin, prolonged blood clotting time).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, seek immediate medical attention.

**HUMAN TOXICITY DATA:** eye-human 5 ppm/2H; inhalation-human TCLo 20ppm/5M; toxic effect: sense organs and special senses (nose, eye, ear, and taste)-conjunctive irritation, sense organs and special senses (nose, eye, ear, and taste)-change in function, gastrointestinal-nausea or vomiting; inhalation-human 10 ppm/3M; toxic effect: gastrointestinal-nausea or vomiting.

**ACUTE HEALTH RISKS:** irritation to eyes, skin and upper respiratory system; irritation to mucous membranes; dry nose and throat; headache; vertigo (dizziness); nausea; malaise

(feeling of illness); weakness; tremor; abnormal cardiovascular system behavior; tachycardia; central nervous system depression; hematopoietic depression; metallic taste.

**CHRONIC HEALTH RISKS:** prolonged exposure may result in damage to liver and kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm (6.1 mg/m<sup>3</sup>); OSHA PEL TWA 10 ppm (60 mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (60 mg/m<sup>3</sup>); NIOSH REL STEL 20 ppm (120 mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, apron, lab coat or coveralls; wear splash-proof safety goggles when working with this chemical; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** stop leak if possible; absorb small quantities on paper; evaporate on a glass or an iron dish in a fume hood, then burn paper; absorb liquid spills with noncombustible materials (e.g., dry earth, sand, vermiculite), and transfer to chemical waste containers; all equipment used when handling the product must be grounded; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; use only with adequate ventilation; storage should be in tightly closed containers; containers should be bonded and grounded to prevent sparking during transfers; separate from oxidizers; keep away from heat and open flames.

**REGULATORY INFORMATION:** T33; T120-a; A1; DOT hazard class division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a solvent for resins; applications as a primary intermediate in chemical industry; utilized mainly as a chemical intermediate for p-tert-butylbenzoic acid.

**KEY REFERENCES:** 4; 5; 6; 7; 12; 15.

## **CADMIUM (C<sub>d</sub>, 112.4)**

**CAS/DOT IDENTIFICATION #:** 7440-43-9/2570

**SYNONYMS:** cadmium metal, CI-77180, colloidal cadmium.

**PHYSICAL PROPERTIES :** soft, silver-white metal; lustrous, malleable metal; hexagonal, closepacked structure; odorless; very ductile; tarnishes in air; soluble in nitric acid and in ammonium nitrate solution; insoluble in water; usually found in combination with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfide); brittle at 80°C; MP (321°C, 610°F); BP (765°C, 1409°C); DN (8.642 g/cm<sup>3</sup> at 20°C); VP(1mmHg at 394°C); MOHS HARDNESS (2.0).

**CHEMICAL PROPERTIES:** combustible; tarnishes in moist air; slowly oxidized by moist air to form cadmium oxide; highly corrosion resistant; corrosion resistance poor in industrial atmospheres; lowers melting point of certain alloys when used in low percentages; resistant to alkalis; reacts vigorously with strong oxidizers, elemental sulfur, selenium and tellurium.

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**EXPLOSION and FIRE CONCERNS:** flammable in powder form; NFPA rating Health 3, Flammability 2, Reactivity 0; reacts violently when heated with ammonium nitrate; vigorous reaction when heated with nitryl fluoride; explodes on contact with hydrazoic acid; incompatible with ignition sources, dust generation, moisture, and excess heat; cadmium and its salts are highly toxic; when heated to decomposition, emits toxic fumes; use dry chemical and carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (throat dryness, coughing, chest pain, headache, irritability); ingestion (vomiting, abdominal pain, increased salivation, anemia).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 39mg/m<sup>3</sup>/20M; inhalation-human TCLo 1500µg/m<sup>3</sup>/14Y; toxic effects: pulmonary carcinogenic; inhalation-man TCLo 88µg/m<sup>3</sup>/8.6Y; toxic effect: kidney; unknown-man LDLo 15mg/kg; inhalation-woman TDLo 129µg/m<sup>3</sup>/20Y; toxic effect: carcinogenic.

**ACUTE HEALTH RISKS:** bronchial and pulmonary edema; impairment of lung function; renal dysfunction; anemia; coughing; tightness of chest; headache; chills; stomach irritation; vomiting; diarrhea; nausea.

**CHRONIC HEALTH RISKS:** emphysema; risk of lung cancer; increased frequency of kidney stone formation; impaired neurological development; skeletal malformations; fragile bones; high blood pressure; decreased birth weights..

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (cadmium dust and cadmium oxide) 0.05mg/m<sup>3</sup>; OSHA PEL TWA (cadmium fumes) 0.1mg/m<sup>3</sup>; OSHA PEL TWA (cadmium dust) 0.2mg/m<sup>3</sup>; NIOSH REL TWA (cadmium) reduce to lowest feasible level; IDLH (cadmium dust or fumes) 40mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** dig a pit, pond, lagoon, or holding area to contain material; seal holding areas with an impermeable flexible membrane liner.

**DISPOSAL AND STORAGE METHODS:** place contained material in plastic-lined impervious containers and transport back to chemical company; recover heavy metal content and deactivate; encapsulate material and place in a sanitary landfill; store in a cool, dry, well ventilated area; storage should be in a tightly closed container, away from heat, flame, and sources of ignition.

**REGULATORY INFORMATION :** S1; S23; S32; S51; S62; R1; R2-5; R4; R7; R8; D waste # (D006); Reportable Quantity (RQ): 10lbs (4.54 kg); Sf1; Sf3; CW5; A1; A2; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in electroplating of automotive, aircraft, and electronic parts; used in fire protection systems; used in photography and lithography; used as a component of batteries.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13; 14.

**CADMIUM (Cd, 112.4)****CAS/DOT IDENTIFICATION #:** 7440-43-9/2570**SYNONYMS:** cadmium metal, CI-77180, colloidal cadmium.

**PHYSICAL PROPERTIES :** soft, silver-white metal; lustrous, malleable metal; hexagonal closepacked structure; odorless; very ductile; tarnishes in air; soluble in nitric acid and in ammonium nitrate solution; insoluble in water; usually found in combination with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfide); brittle at 80°C MP; (321°C, 610°F); BP (765°C, 1409°C); DN (8.642 g/cm<sup>3</sup> at 20°C); VP(1 mmHg at 394°C); Mohs hardness (2.0).

**CHEMICAL PROPERTIES:** combustible; tarnishes in moist air; slowly oxidized by moist air to form cadmium oxide; highly corrosion resistant; corrosion resistance poor in industrial atmospheres; lowers melting point of certain alloys when used in low percentages; resistant to alkalis; reacts vigorously with strong oxidizers, elemental sulfur, selenium and tellurium.

**EXPLOSION and FIRE CONCERNS:** flammable in powder form; NFPA rating Health 3, Flammability 2, Reactivity 0; reacts violently when heated with ammonium nitrate; vigorous reaction when heated with nitryl fluoride; explodes on contact with hydrazoic acid; incompatible with ignition sources, dust generation, moisture, and excess heat; cadmium and its salts are highly toxic; when heated to decomposition, emits toxic fumes; use dry chemical and carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (throat dryness, coughing, chest pain, headache, irritability); ingestion (vomiting, abdominal pain, increased salivation, anemia).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 39mg/m<sup>3</sup>/20m; inhalation-human TCLo 1500µg/m<sup>3</sup>/14Y; toxic effects: pulmonary carcinogenic; inhalation-man TCLo 88µg/m<sup>3</sup>/8.6Y; toxic effect: kidney; unknown-man LDLo 15mg/kg; inhalation-woman TDLo 129µg/m<sup>3</sup>/20Y; toxic effect: carcinogenic.

**ACUTE HEALTH RISKS:** bronchial and pulmonary edema; impairment of lung function; renal dysfunction; anemia; coughing; tightness of chest; headache; chills; stomach irritation; vomiting; diarrhea; nausea.

**CHRONIC HEALTH RISKS:** emphysema; risk of lung cancer; increased frequency of kidney stone formation; impaired neurological development; skeletal malformations; fragile bones; high blood pressure; decreased birth weights.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (cadmium dust and cadmium oxide) 0.05mg/m<sup>3</sup>; OSHA PEL TWA (cadmium fumes) 0.1mg/m<sup>3</sup>; OSHA PEL TWA (cadmium dust) 0.2mg/m<sup>3</sup>; NIOSH REL TWA (cadmium) reduce to lowest feasible level; IDLH (cadmium dust or fumes) 40mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** dig a pit, pond, lagoon, or holding area to contain material; seal holding areas with an impermeable flexible membrane liner.

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**DISPOSAL AND STORAGE METHODS:** place contained material in plastic-lined impervious containers and transport back to chemical company; recover heavy metal content and deactivate; encapsulate material and place in a sanitary landfill; store in a cool, dry, well ventilated area; storage should be in a tightly closed container, away from heat, flame, and sources of ignition.

**REGULATORY INFORMATION :** S1; S23; S32; S51; S62; R1; R2-5; R4; R7; R8; D waste # (D006); Reportable Quantity (RQ): 10lbs (4.54 kg); Sf1; Sf3; CW5; A1; A2; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in electroplating of automotive, aircraft, and electronic parts; used in fire protection systems; used in photography and lithography; used as a component of batteries.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13; 14.

### **CALCIUM HYDROXIDE (Ca(OH)<sub>2</sub>, 74.10)**

**CAS/DOT IDENTIFICATION #:** 1305-62-0/ none

**SYNONYMS:** calcium dihydroxide, calcium hydrate, caustic lime, hydrated lime, slaked lime.

**PHYSICAL PROPERTIES :** colorless crystals or soft, white granules or powder; hexagonal or rhombic, trigonal crystals; odorless; slightly bitter, alkaline taste; soluble in glycerol, sugar, and ammonium chloride solution; soluble in ammonium salts and acids; insoluble in alcohol; slightly soluble in water; MP (580°C, 1076°F); BP (decomposes); DN (2.08-2.34 g/cm<sup>3</sup>); SG (2.24 at 20°C); CP (87.5 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; readily absorbs carbon dioxide from air to form calcium carbonate; loses water when ignited to form calcium oxide; strongly alkaline material; FP (NA); LFL/UFL (NA); AT (NA); HF (-985.2kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating Health 3, Flammability 0, Reactivity 0; not considered to be a fire hazard or an explosion hazard; violent reaction with maleic anhydride, nitromethane, nitroethane, nitropropane, nitroparaffins, and phosphors; reacts violently with acids, with evolution of much heat; attacks many metals in presence of water forming flammable/explosive gas; forms extremely toxic products when it reacts with polychlorinated phenol and potassium nitrate; caustic fumes of calcium oxide form when heated to decomposition; use any means suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sore throat, cough, burning sensation); skin contact (redness, roughness, pain, dry skin, skin burns, blisters); eye contact (redness, pain, severe deep burns); ingestion (burning sensation, abdominal pain, abdominal cramps, vomiting).

**FIRST AID:** rinse eyes with plenty of water for several minutes; immediately flush skin with plenty of water for several minutes; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, give large quantities of water; do not induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to upper respiratory tract; coughing; sore throat; burning sensation; shortness of breath; chemical bronchitis; abdominal pain; abdominal cramps; vomiting; diarrhea; esophageal perforation; fall in blood pressure; narrowing of the esophagus; difficulties in swallowing; severe skin burns; blistering; ulcerations of the corneal epithelium; may cause blindness; death may occur in 24 hours.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact with skin may produce severe irritation or dermatitis; lungs may be affected by repeated or prolonged exposure to dust particles.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (5 mg/m<sup>3</sup>); OSHA PEL TWA 15(total dust)mg/m<sup>3</sup>, 5mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; IDLH (NA).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or full face shield where dusting or splashing of solutions is possible; appropriate respirators with dust/mist filters are needed in areas where exposure would be above the permissible exposure level (PEL); use a full-facepiece positive pressure, self-contained breath apparatus in instances where the exposure levels are not known; P2 filter respirators are recommended for harmful particles; maintain eye-wash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; sweep spilled substance into suitable containers, using a method that does not generate dust; dilute residues from spills with water, or neutralize with dilute acid such as acetic, hydrochloric or sulfuric; absorb neutralized caustic residue on clay, vermiculite or other inert substance and package in a suitable container for disposal.

**DISPOSAL AND STORAGE METHODS:** following neutralization of caustic residue either at spill site or at a waste management facility, the resultant sludge can be disposed of in a secured, sanitary landfill; store in a cool, dry, well-ventilated area; keep in tightly closed containers; protect against physical damage; isolate from incompatible substances, including maleic anhydride, nitroethane, nitromethane, nitroparaffins, nitropropane, and phosphorus.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used in mortar, plasters, cements, and other building and paving materials; used in the recovery of ammonia in gas manufacture, in water softening, and in the purification of sugar juices; useful as an accelerator for low-grade rubber compounds; also used as a depilatory, a soil conditioner, and a food additive as buffer and neutralizing agent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 11; 14.

## **CALCIUM OXIDE(CaO, 56.08)**

**CAS/DOT IDENTIFICATION #:** 1305-78-8/UN1910

**SYNONYMS:** burned lime, burnt lime, calcia, lime, pebble lime, quick lime, unslaked lime.

**PHYSICAL PROPERTIES :** cubic, colorless, white crystals; white or grayish-white lumps or granular powder; commercial material sometimes has a yellowish or brownish tint, due to iron; odorless; bitter alkaline taste; soluble in acids, glycerol, and sugar solution; practically insoluble in alcohol; soluble in water; MP (2614°C, 4737°F); BP(2850°C, 5162°F); DN

(3.32-3.35 g/cm<sup>3</sup> at 20°C); SG (3.34); CP (42.0 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg).

**CHEMICAL PROPERTIES:** noncombustible solid, but will support combustion by liberation of oxygen; readily absorbs carbon dioxide and water from air, becoming airslaked; reacts with water to form calcium hydroxide (alkaline) solution; reacts with acids; becomes incandescent when heated to near its melting point; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-634.9 kJ/mol crystal at 25°C); H<sub>f</sub> (59 kJ/mol at 3200K).

**EXPLOSION and FIRE CONCERNS:** not combustible, but powdered oxide may heat spontaneously when damp with water; NFPA rating Health 3, Flammability 0, Reactivity 1; mixtures with ethanol may ignite if heated and therefore can result in an air-vapor explosion; reacts violently with boron oxide and calcium chloride, fluoride, hydrogen fluoride, boron trifluoride, chlorine pentafluoride, and phosphorus pentoxide and heat; incandescent reaction with liquid hydrogen fluoride; incompatible with phosphorus (V) oxide; use dry chemical or carbon dioxide on adjacent fires for firefighting purposes; avoid using water on other burning materials if possible; if unavoidable, use flooding quantities of water spray to absorb heat generated.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, and respiratory system); skin absorption (combines with sweat to produce highly irritating alkaline solution and burning sensation); contact (severe irritation of skin and mucous membranes).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** no toxicity data is available for calcium oxide.

**ACUTE HEALTH RISKS:** irritation of eyes and upper respiratory tract; destructive to tissues of mucous membranes; sneezing; ulceration or perforation of nasal septum; pneumonia; severe irritation of skin.

**CHRONIC HEALTH RISKS:** dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2mg/m<sup>3</sup>; OSHA PEL TWA 5mg/m<sup>3</sup>; NIOSH REL TWA 2mg/m<sup>3</sup>; IDLH 25 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear rubber overclothing; rubber gloves are also recommended; use chemical safety goggles and any type of respirator prescribed for fine dust.

**SPILL CLEAN-UP:** ventilate area of spill; shovel spilled material into suitable dry containers and place in a secured sanitary landfill; use water spray to control dust; wash liquid spills with buffer or mild acid solution; neutralize with natural carbon dioxide and precipitate calcium carbonate.

**DISPOSAL AND STORAGE METHODS:** pour into large tank of water and neutralize; transfer to sewer with large excess of water; spilled material deposited in sealed containers may be used as fill in reclaiming low areas or may be dumped into a landfill; store in a cool, dry area with adequate ventilation; storage should be in a tightly sealed containers; keep away from organic materials.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used in building and construction materials such as bricks, plaster, mortar, and stucco; used in the manufacture of steel, aluminum, magnesium, glass, and

paper; used in the production of sodium carbonate by Solvay process, calcium salts and many other industrial chemicals; useful in water and sewage treatment (phosphate removal, pH control) and in the removal of sulfur dioxide from stack gases; also used in the clarification of cane and beet sugar juices; an absorbent for carbon dioxide.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 11; 14.

### **CALCIUM SILICATE (CaSiO<sub>3</sub>, 116.16)**

**CAS/DOT IDENTIFICATION #:** 1344-95-2/none

**SYNONYMS:** calcium hydrosilicate, calcium metasilicate, calcium monosilicate, calcium polysilicate, calcium salt of silicic acid, wollastonite (mineral).

**PHYSICAL PROPERTIES :** white or slightly cream colored powder; free-flowing material; prepared commercially from lime and diatomaceous earth; insoluble in water; forms a silicon gel with mineral acids; remains a free-flowing powder even when it absorbs 1 to 2.5 times its weight of liquids; total absorption power for water about 600%, for mineral oil about 500%; available surface area: 95-175 m<sup>2</sup>/g; ultimate particle size: 0.02-0.07 microns; MP (1,540°C, 2,804°F); BP (unknown); DN (2.10 g/cm<sup>3</sup> at 25°C); BULK DN (15-16 lb/ft<sup>3</sup>); SG (2.9 at 20°C); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; no incompatibilities reported; after prolonged contact with water, solution will revert to soluble calcium salts and amorphous silica; no hazardous decomposition products reported; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); not expected to be a fire hazard; no incompatibilities or hazardous reactions reported; no hazardous decomposition products reported; no special precautions reported; in case of fire in the surroundings, all extinguishing agents are allowed.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory tract); contact (eruptions of the skin, painful, red eyes).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, rinse mouth several times with water; induce vomiting by giving syrup of ipecac and seek immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to upper respiratory system; pain and redness of eyes; itching, redness, and eruptions of skin; scratchiness of the throat.

**CHRONIC HEALTH RISKS:** may cause dermal irritation after prolonged contact; may cause possible induction of altered pulmonary function and lesions when silica or asbestos are present.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg (total dust)/m<sup>3</sup>; OSHA PEL TWA 15 mg (total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear full protective clothing, including chemical-resistant gloves, apron or coveralls; wear dust-proof safety goggles or face shields during operations; an enclosed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure limits; for extra personal protection, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill of leak; use a wet method vacuuming to clean up material; place material into a clean, dry container; cove and remove container from spill area.

**DISPOSAL AND STORAGE METHODS:** if appropriate, first moisten spill and then deposit in sealed containers for disposal in a designated landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; use with adequate ventilation; storage should be in tightly closed containers.

**REGULATORY INFORMATION:** A1.

**OTHER COMMENTS:** used as a constituent of lime glass and Portland cement; used as a reinforcing filler in elastomers and plastics, ceramics, paints, paper, and wallboard; utilized as an aggregate in road construction, as a thermal insulator, and as a paper coating in chromatography; useful as an absorbent for liquids, gases and vapors; has also been used as an attacking ingredient in table salt baking powder, foods, powdered pharmaceuticals, and cosmetics.

**KEY REFERENCES:** 3; 4; 5; 6; 15; 16.

### **CALCIUM SUFLATE (CaSO<sub>4</sub>, 136.14)**

**CAS/DOT IDENTIFICATION #:** 7778-18-9/none

**SYNONYMS:** anhydrite, anhydrous calcium sulfate, anhydrous gypsum, anhydrous sulfate of lime, calcium salt of sulfuric acid.

**PHYSICAL PROPERTIES :** white powder or colorless, crystalline solid; color may vary, e.g., white with blue, gray or reddish tinge, or brick red; crystals are orthorhombic; odorless; tasteless powder; slightly solubility in water; practically insoluble in most organic solvents; dissolves in acids; MP (1560°C, 2840°F); BP (1193°C, 2179°F decomposes); DN (2.964 g/cm<sup>3</sup>); SG (2.96); CP (99.7 J/K-mol crystal at 25°C); VD (NA); VP ( 0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; very hygroscopic (i.e., absorbs moisture from the air); reacts with water to form Gypsum and Plaster of Paris; FP (NA); LFL/UFL (NA); AT (NA); HF (-1434.5 kJ/mol crystal at 25°C); H<sub>f</sub> (28.03 kJ/mol at 1723K).

**EXPLOSION and FIRE CONCERNS:** non combustible solid; not considered to be a fire hazard; NFPA rating Health 1, Flammability 0, Reactivity 0; not considered to be an explosion hazard; considered a nuisance dust; mixtures with diazomethane heat exothermically and eventually explode; violent reaction with aluminum when heated; mixtures with phosphorus ignite at high temperatures; burning may produce oxides of sulfur; use any mean suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, shortness of breath, irritates upper respiratory tract); eye contact (redness, pain, irritation, conjunctivitis); skin contact (redness, pain, irritation); ingestion (stomach pain, distress, stomach obstruction).

**FIRST AID:** flush eyes with plenty of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, give oxygen; if not breathing, give respiratory support; if ingested, induce vomiting immediately and get medical attention; drink large volumes of water, glycerin, or gelatin solutions to delay the hardening of calcium sulfate in the stomach.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory system; coughing; shortness of breath; rhinorrhea (discharge of thin nasal mucus); epistaxis (nosebleed); conjunctivitis; stomach pain; may cause obstruction in stomach, as it hardens with moisture.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; use dust- and splash-proof safety goggles; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; a system of local and/or general exhaust ventilation is recommended; in the event of a fire, wear self-contained breathing apparatus with full face-piece operated in positive pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; sweep up spills and containerize for reclamation or disposal; use vacuuming or wet sweeping in order to avoid dust dispersal.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated area; keep in tightly closed containers and protect against physical damage; avoid; air, moisture, and incompatibles.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** insoluble anhydrite is used in cement formulations and as a paper filler; soluble anhydrite is useful as a drying agent for solids, organic liquids and gases, due to its strong tendency to absorb moisture; gypsum is the dihydrate form and is used in the manufacture of Portland Cement, Plaster of Paris, and artificial marble; Plaster of Paris is the hemihydrate form and is used for wall plaster, wallboard, moldings, and tiles and blocks for the building industry.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**CAMPHOR, SYNTHETIC (C<sub>10</sub>H<sub>16</sub>O, 152.26)**

**CAS/DOT IDENTIFICATION #:** 76-22-2/UN2717

**SYNONYMS:** 2-camphanone, gum camphor, laurel camphor, synthetic camphor.

**PHYSICAL PROPERTIES** : colorless or white translucent mass with crystalline fracture; rhombohedral crystals from alcohol; cubic crystals by melting and chilling; penetrating, aromatic odor; slightly bitter and cooling taste; may be powdered in a mortar when moistened with an organic solvent; liquefies when triturated with chloral hydrate, menthol, resorcinol,  $\beta$ -naphthol, thymol, and phenol; soluble in aniline, nitrobenzene, carbon disulfide, decalin, tetralin, methylhexalin, petroleum ether, in the higher alcohols, and in fixed and volatile oils; also soluble in concentrated mineral acids in phenol, in liquid sulfur dioxide, and liquid ammonia; insoluble in water; MP (174°C, 345°F); BP (204°C, 399°F); DN (0.922 g/cm<sup>3</sup> at 25°C); SG (0.99); CP (271.2 J/K-mol crystal at 25°C); HV (59.5 kJ/mol at 480K); VD (5.24); VP (0.2 mmHg at 20°C); OT (1.6 ppm in air).

**CHEMICAL PROPERTIES**: combustible solid; sublimes appreciably at room temperature and pressure; optically inactive; very volatile in steam; can react with oxidizing agents; also reacts with chromic anhydride, potassium permanganate, naphthalene, dichlorobenzene, organic solvents, and chlorates; FP (65.6°C, 150°F); LFL/UFL (0.6%, 3.5%); AT (466°C, 871°F); HF (-319.4 kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS**: combustible; NFPA rating Health 0, Flammability 2, Reactivity 0; flammable liquid when exposed to heat or flame; reacts violently with chromic anhydride and naphthalene; vapor is explosive when exposed to heat or flame or chromium (III) oxide; burning may increase hazardous vapor levels; incompatible with potassium permanganate; salts of any kind should not be added to camphor water; use dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (irritates eyes, skin, and mucous membranes); ingestion (nausea, vomiting, dizziness, headache, confusion, excitement, restlessness, delirium, tremors, epileptiform convulsions, depression, coma, death); absorption (injury through dermal penetration).

**FIRST AID**: wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA**: oral-infant LDLo 70mg/kg; unknown-man LDLo 29 mg/kg.

**ACUTE HEALTH RISKS**: irritates eyes, skin and mucous membranes; nausea; vomiting; vertigo; excitation; mental confusion; delirium; convulsions; respiratory failure; feeling of warmth; headache; restlessness; hallucinations; increased muscular excitability; tremors; jerky movements; depression; coma; death from respiratory failure.

**CHRONIC HEALTH RISKS**: central nervous system depression; slow convalescence; persistent gastric distress; mutation data reported.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 2 ppm; ACGIH TLV STEL 3ppm; OSHA PEL TWA 2 mg/m<sup>3</sup>; NIOSH REL TWA 2mg/m<sup>3</sup>; IDLH 200 mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear full protective clothing (boots, sleeves, aprons, etc.); rubber gloves are recommended; wear safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP**: estimate vapor concentrations and if potentially high, evacuate downwind areas; use water spray to cool and disperse vapors; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS**: pipe gas into incinerator and allow it to burn away; atomize large amounts of liquid into an incinerator equipped with afterburner and scrubber or dissolve in a more flammable solvent and burn in incinerator; for solids, dissolve in a

flammable solvent and spray into a suitable combustion chamber; store in a cool, dry, well-ventilated location; isolate from heat or other sources of ignition.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (4.2); labels (flammable solid).

**OTHER COMMENTS:** an excellent plasticizer for cellulose esters and ethers; used in the manufacture of plastics, lacquers and varnishes; used in explosives, moth repellents, in embalming fluids, and tooth powders; useful as a preservative in pharmaceuticals and cosmetics.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 11; 14.

### **CARBARYL (C<sub>12</sub>H<sub>11</sub>NO<sub>2</sub>, 201.24)**

**CAS/DOT IDENTIFICATION #:** 63-25-2/UN2757

**SYNONYMS:** alpha-naphthyl n-methylcarbamate, 1-naphthyl n-methylcarbamate, ravyon, sevin<sup>®</sup>, vioxin.

**PHYSICAL PROPERTIES :** white or gray solid; colorless solid; odorless; soluble in dimethylformamide (DMF); soluble in dimethyl sulfoxide, acetone, cyclohexanone, isopropanol, and xylene; freely soluble in chloroform; slightly soluble in water; MP (145°C, 293°F); BP (decomposes); DN (1.232 g/cm<sup>3</sup> at 20°C); SG (1.23); VP (<0.00004mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable to heat, light and acids; hydrolyzed in alkalis; non-corrosive; decomposes at its boiling point; reacts vigorously with strong oxidizers and strongly alkaline pesticides.

**EXPLOSION and FIRE CONCERNS:** decomposes on heating; NFPA rating (not rated); fine dust explosive with air; forms toxic gases and vapors, such as oxides of nitrogen, methylamine, and carbon monoxide; decomposition emits toxic fumes of NO<sub>x</sub>; may generate electrostatic charges; incompatible with strong oxidizing agents and strongly alkaline pesticides; use water spray, foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (miosis, blurred vision); skin absorption (rhinitis, excessive salivation, sweating); ingestion (abdominal cramps, nausea, vomiting).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** mma-human: fibroblast 1μmol/L; dns-human: fibroblast 1μmol/L; cyt-human: embryo 40μg/kg; oral-man TDLo 500mg/kg; toxic effect: peripheral nervous system.

**ACUTE HEALTH RISKS:** eye and skin irritation; respiratory failure; convulsions; slow pulse; muscle weakness; ataxia; cyanosis; central nervous system depression; bronchoconstriction; headache; nausea; vomiting; diarrhea; blurred vision; coma

**CHRONIC HEALTH RISKS:** kidney and liver effects; respiratory and heart failure; muscle weakness; memory loss; dyspnea; anorexia; dermatitis; cholinesterase inhibition.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5mg/m<sup>3</sup>; OSHA PEL TWA 5mg/m<sup>3</sup>; NIOSH REL TWA 5mg/m<sup>3</sup>; IDLH 100mg/m<sup>3</sup>.

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**PERSONAL PROTECTION:** wear a gas-tight suit and filter mask; use compressed air/oxygen apparatus or any self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area; dissolve in flammable solvent (such as alcohol), and atomize in suitable combustion chamber; carbon or peat may be used as sorbents.

**DISPOSAL AND STORAGE METHODS:** mix with flammable solvent and spray into incinerator equipped with afterburner and scrubber; add to strong alkaline solution of calcium hypochlorite and route cyanate to sewage treatment plant; absorb with carbon or peat and place in a sanitary landfill.

**REGULATORY INFORMATION :** CA2; F2; F5; F8; R4; U waste # (U279); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf3; CW1; CW2; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as an insecticide for corn, cotton, livestock, and poultry; used in agriculture to control earthworms in turf; used to control fleas, lice, ticks, and mites on animals and poultry.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13; 14.

### **CARBON BLACK (C, 12.0)**

**CAS/DOT IDENTIFICATION #:** 1333-86-4/none

**SYNONYMS:** acetylene black, black pearls, channel black, furnace black, lamp black, thermal black, united, velvetex, vulcan, wyex

**PHYSICAL PROPERTIES :** extremely fine, smoke-like powder or black solid; odorless; x-ray diffraction reveals a structure similar to, but less regular than graphite; particle sizes range from 5-500 nanometers; appears spherical under electron microscope; insoluble in all solvents; insoluble in water; MP (sublimes); BP (4200°C, 7592°F); DN (1.8-2.1 g/cm<sup>3</sup> at 20°C); SG (1.8-2.1); VP (negligible at 20°C).

**CHEMICAL PROPERTIES:** combustible solid that may contain flammable hydrocarbons; can react vigorously with strong oxidizers such as chlorates, bromates, and nitrates; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** flammable/combustible material; NFPA rating (NA); may be ignited by friction, heat, sparks, or flames; burns slowly with production of carbon monoxide; some may burn rapidly with flare burning effect; powders, dusts, shavings, borings, turnings or cuttings may explode or burn violently; should be considered as an explosion hazard when it exceeds 8% volatile material; may re-ignite after fire is extinguished; can undergo spontaneous heating when mixed with fatty oils or sodium sulfide; reacts violently with nitric acid; not compatible with strong oxidizers such as perchlorates, peroxides, permanganates, chlorates, and nitrates; fire may produce irritating and/or toxic gases; runoff from fire control may cause pollution; substance may be transported in a molten form; use dry chemical, carbon dioxide, sand, earth, water spray or regular foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, difficult breathing, obstructive airway disease, bronchitis, irritates eyes, nose and throat); skin contact (produces a tattooing effect consisting of black follicular dots, severe skin irritation and/or burns).

**FIRST AID:** eyes should be irrigated with large amounts of water for at least fifteen minutes; wash affected areas of skin thoroughly with soap and water; provide oxygen or respiratory support; if swallowed, rinse mouth several times with cold water and then drink plenty of water or milk.

**HUMAN TOXICITY DATA:** minimum lethal human exposure to this agent has not been described; a significant loss in pulmonary function was reported in a group of 125 Nigerian carbon black workers exposed to levels of up to  $34\text{mg/m}^3$ .

**ACUTE HEALTH RISKS:** irritation of eyes, nose and respiratory tract; dryness in the throat; coughing; wheezing; severe eye and skin burns; may cause discoloration of lids and conjunctivae.

**CHRONIC HEALTH RISKS:** chronic bronchitis with cough, phlegm, shortness of breath; pneumoconiosis; emphysema; fibrosis; may cause lung cancer; can accumulate in the skin producing a tattooing effect called anthracosis, consisting of black follicular dots; can interact with disease states (e.g., tuberculosis) or other exposures (e.g. smoking) to reduce pulmonary function.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $3.5\text{ mg/m}^3$ ; OSHA PEL TWA  $3.5\text{ mg/m}^3$ ; NIOSH REL TWA  $3.5\text{ mg/m}^3$ ; NIOSH REL TWA  $0.1\text{ mg PAHs/m}^3$  (carbon black in presence of polycyclic aromatic hydrocarbons); IDLH  $1750\text{ mg/m}^3$ .

**PERSONAL PROTECTION:** wear appropriate full body clothing with elastic cuffs at the wrists and ankles, chemical-resistant gloves, and footwear; wear dust-proof safety goggles when working with powders or dust; use self-contained breathing apparatus operated in a positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill or leak; for small dry spills, clean shovel powdered material into clean, dry container and cover loosely; move containers from spill area; large spills may be collected by vacuuming with an appropriate high efficiency filtration system or by wetting down with water for later disposal; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** systems of electrostatic precipitators, cyclones, and bag filters will collect over 99% of the black in thermal and furnace process plants; after the black has been removed, large quantities of waste gases can be atomized in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a dry, well-ventilated area, away from sources of heat or ignition; keep away from oxidizing agents and other incompatibles; most stable when stored in closed containers at room temperature.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a pigment for rubber tires, for printing, stenciling, drawing inks, leather, and stove polish; also used as a pigment in eye cosmetics; primarily used as reinforcing filler for rubber and for its ability to improve resistance to breaking, tear and abrasion; used extensively in ink, varnish and paint industries as pigment; applications as an excellent high temperature insulating material and as a source of pure carbon both for ore reduction and carburizing; carbon brushes and electrodes are fabricated from carbon black; useful as a thickener in some high temperature petroleum and synthetic greases.

**KEY REFERENCES:** 4; 5; 6; 7; 15.

**CARBON DIOXIDE (CO<sub>2</sub>, 44.01)**

**CAS/DOT IDENTIFICATION #:** 124-38-9/UN1013, UN1845(dry ice), N2187(liquid).

**SYNONYMS:** carbonic acid anhydride, carbonic acid gas, carbonic anhydride, carbon oxide, dry ice.

**PHYSICAL PROPERTIES :** colorless gas; odorless; faint acid taste; usually shipped under sufficient pressure to keep it liquid; solid form is utilized as dry ice, resembling white, snow-like flakes or cubes; when shipped in steel cylinders, it is in the form of gas over liquid and exerts a pressure of 830 psi at 20°C; solid form changes into the gaseous phase without liquefaction at atmospheric pressures; gas is heavier than air and may accumulate in low ceiling spaces causing an oxygen deficiency; free-flowing liquid condenses to form extremely cold dry ice; slightly soluble in water; more soluble at higher pressures; less soluble in alcohol and other neutral organic solvents; sublimates at -78.5°C (-109°F) at 760 mmHg; triple point exists at -56.6°C (-70°F) at 5.11 atm; MP (-56.6°C, -70°F at 5.2 atm); BP (sublimes); DN (1.976 g/L gas at 0°C and 760 mmHg, 0.914 g/mL liquid at 0°C and 34.3 atm, 1.512 g/cm<sup>3</sup> solid at -56.6°C); VS (14.9 μPa-s gas at 25°C); CP (37.1 J/K-mol gas at 25°C); LHV (83.12 gcal/g); VD (1.5); VP (10.5 mmHg at -120°C, 104.2 mmHg at -100°C, 569.1 mmHg at -82°C).

**CHEMICAL PROPERTIES:** nonflammable gas; forms carbonic acid in water; absorbed by alkaline solutions with the formation of carbonates; gas is affected by heat when the temperature reaches about 2000°C; reacts vigorously with cesium oxide, lithium, potassium, sodium, titanium, aluminum and sodium peroxide, magnesium and sodium peroxide, and diethyl magnesium; FP (NA); LFL/UFL (NA); AT (NA); HF (-393.5 kJ/mol gas at 25°C); T<sub>c</sub> (31.3°C, 88.3°F); P<sub>c</sub> (72.9 atm, 55,404 mmHg).

**EXPLOSION and FIRE CONCERNS:** noncombustible gas; usually a non-supporter of combustion, although metal dusts of magnesium, zirconium, titanium, aluminum, chromium and manganese ignite and then explode in CO<sub>2</sub> atmospheres; reacts violently with strong bases and alkali metals; several bulk metals will burn in CO<sub>2</sub>; CO<sub>2</sub> fire extinguishers can produce sparks of 5-15 mJ at 10-20kV by electrostatic discharge; build-up of static electricity can occur at fast flow rates and may ignite any explosive mixtures present; incompatible with acrylaldehyde, aziridine, sodium peroxide, and metal acetylides; decomposes on heating above 2000°C, producing toxic carbon monoxide; all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, tachycardia, elevated blood pressure, hyperventilation, suffocation, unconsciousness); contact (rapid evaporation of liquid may cause serious frostbite and blisters).

**FIRST AID:** rinse eyes with plenty of water for several minutes; rinse skin with plenty of water and get immediate medical attention; if breathing is difficult, provide oxygen; if breathing has stopped, administer artificial respiration.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 9pph/5M.

**ACUTE HEALTH RISKS:** headache, dizziness, restlessness; paresthesia; dyspnea; sweating; increased heart rate; elevated blood pressure; malaise; hyperventilation; asphyxia; convulsions; coma; frostbite (dry ice).

**CHRONIC HEALTH RISKS:** effects on metabolism; possibly causes toxic effects upon human reproduction.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5000 ppm; ACGIH TLV STEL 30,000 ppm; OSHA PEL TWA 5000 ppm (9000 mg/m<sup>3</sup>); NIOSH REL TWA 5000 ppm (9000 mg/m<sup>3</sup>); NIOSH REL STEL 30,000 ppm (54,000 mg/m<sup>3</sup>); IDLH 40,000 ppm.

**PERSONAL PROTECTION:** wear protective clothing, including cold-insulating gloves; chemical safety goggles or face shield are recommended; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill or leak; turn leaking cylinder with the leak up to prevent escape of gas in liquid state; use water spray to cool and disperse vapors; never direct water jet on liquid.

**DISPOSAL AND STORAGE METHODS:** on loss of containment, liquid evaporates very quickly causing supersaturation of air; contain in steel cylinders, under sufficient pressure to keep it liquid; store in a cool, dry location with adequate ventilation; fireproof if in building.

**REGULATORY INFORMATION:** F2; F7; A1; CAL; DOT hazard class/division (2.2); labels (nonflammable gas); DOT hazard class/division (9); labels (none)(UN1845).

**OTHER COMMENTS:** used in carbonated beverages by contributing the characteristic pungent taste and inhibiting the growth of mold and bacteria; used in firefighting and extinction; gas is used in oil recovery to maintain pressure underground as oil is pumped away; promotes plant growth in greenhouses; used as dry ice for refrigeration; used for inerting flammable materials during manufacturing, handling and transfer; mainly used as a refrigerant in the frozen food industry and as an antiseptic in bacteriology.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

## **CARBON DISULFIDE (CS<sub>2</sub>, 76.13)**

**CAS/DOT IDENTIFICATION #:** 75-15-0/UN1131

**SYNONYMS:** carbon bisulfide, carbon sulfide, dithiocarbonic anhydride.

**PHYSICAL PROPERTIES :** colorless to faint-yellow liquid; when pure, sweet ether-like odor; reagent grades are foul smelling, like rotten eggs; mobile liquid; soluble in chloroform, alcohol and ether; miscible with anhydrous methanol and benzene; slightly soluble in water; MP (-115°C, -168.7°F); BP (46.5°C, 115.7°F at 760 mmHg); DN (1.2632 g/cm<sup>3</sup> at 20°C); LSG (1.26 at 20°C); ST (32 dynes/cm at 20°C); VS (0.352 MPa-s at 298.15K); HV (84.1 cal/g at 46°C); VD (2.64); VP (300 mmHg at 20°C); OT (0.1 - 0.2 ppm).

**CHEMICAL PROPERTIES:** corrosive liquid; reacts with strong oxidizing materials to produce oxides of sulfur and carbon monoxide; forms an azeotrope with water at 42.6°C; FP (-30°C, -22°F); LFL/UFL (1.3%, 50.0%); AT (99°C, 210°F); HC (-5814 Btu/lb, -3230cal/g, -135.2 x 10<sup>5</sup> J/kg); H<sub>f</sub> (1049 kcal/mole); DEC (2.641 at low frequencies); Pc (72.9 atm at 20°C); Tc (280°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; dangerous fire hazard when exposed to heat, flame, sparks, and friction; forms explosive mixtures with air over a wide range; mixtures with sodium or potassium-sodium alloys are powerful, shock-sensitive explosives; ignites when heated in contact with rust or iron; potentially explosive reaction with nitrogen oxide; explodes on contact with permanganic acid; reacts violently with azides; vapor ignites on contact with fluorine; aluminum powder ignites in carbon disulfide vapor; incompatible with air, metals, halogens, amines, and

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strong oxidizers; decomposition emits highly toxic fumes of  $\text{SO}_x$ ; use water spray, carbon dioxide, dry chemical powder, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of skin, eyes, and mucous membranes, garlicky breath, palpitations); skin absorption (headaches, vertigo, fatigue).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 4000ppm/30M; inhalation-human LCLo 2000ppm/5M; inhalation-man TCLo  $40\text{mg}/\text{m}^3$ ; sce-human: lymphocyte 10,200  $\mu\text{g}/\text{L}$ ; unr-man LDLo 186mg/kg..

**ACUTE HEALTH RISKS:** irritation to eyes, mucous membranes, and upper respiratory tract; respiratory failure; headache; dizziness; blurred vision; convulsions; delirium; nausea; vomiting; chest pains; lethargy; fatigue..

**CHRONIC HEALTH RISKS:** angina; coronary heart disease; neurophysiological changes; behavioral changes; muscle pain; ocular effects; anorexia; decreased sperm count in men; menstrual disturbances in women.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $31\text{mg}/\text{m}^3$ ; OSHA PEL TWA  $12\text{mg}/\text{m}^3$ ; NIOSH REL TWA 1ppm ( $3\text{mg}/\text{m}^3$ ); IDLH 500pm.

**PERSONAL PROTECTION:** wear rubber protective clothing, aprons and gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; prohibit entrance into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** cautiously ignite small amounts in open areas; atomize large amounts in a suitable combustion chamber; outside storage preferred; store bulk quantities under water or inert gas blanket.

**REGULATORY INFORMATION :** CA2; S10; F2; R2-22; R3; R4; R5; R6; R8; P waste #(P022); Reportable Quantity (RQ): 100lbs. (45.4 kg); Sf1; Sf2; Sf3; CW1; CW2; T30-e13; T120-d13; A1 A2; CAL; DOT hazard class/division (3); labels (flammable liquid, poison).

**OTHER COMMENTS:** used in the manufacture of rayon, carbon tetrachloride, soil disinfectants, and electronic vacuum tubes; used as a solvent for phosphorus, selenium, sulfur, bromine, and iodine.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 12; 13; 14.

### CARBON MONOXIDE (CO, 28.01)

**CAS/DOT IDENTIFICATION #:** 630-08-0/UN1016

**SYNONYMS:** carbonic oxide, carbon oxide, exhaust gas, flue gas, monoxide.

**PHYSICAL PROPERTIES :** colorless gas; odorless and tasteless; burns in air with a bright blue flame; soluble in benzene, ethyl acetate, chloroform, and acetic acid; freely absorbed by a concentrated solution of cuprous chloride in hydrochloric acid or ammonium hydroxide; very slightly soluble in water; solubility is about 7 times greater in methanol and

ethanol than that in water; MP (-205°C, -337°F); BP (-192°C, -313°F); DN (1.250 g/L gas at 0°C); VD (0.97); CP (6.95 cal/mol/°C at 20°C); LHV (92.8 Btu/lb, 51.6 cal/g,  $2.16 \times 10^5$  J/kg); VP (>760 mmHg at 20°C).

**CHEMICAL PROPERTIES:** flammable gas; combines with hemoglobin of the blood to form carboxyhemoglobin; decomposes into carbon and carbon dioxide at 400-700°C; decomposes at lower temperatures when in contact with catalytic surfaces; reacts vigorously with strong oxidizing materials and halogen compounds; FP (NA); LFL/UFL (12.5%, 74%); AT (700°C, 1292°F); HC (-4,342 Btu/lb, -2,412 cal/g,  $-101 \times 10^5$  J/kg); HF (-26.39 kcal/mol).

**EXPLOSION and FIRE CONCERNS:** flammable gas; NFPA rating Health 3, Flammability 4, Reactivity 0; dangerous fire hazard; severe explosion hazard when exposed to heat or flame; reacts violently on contact with bromine trifluoride, bromine pentafluoride, chlorine dioxide, or peroxodisulphuryl difluoride; liquid carbon monoxide forms explosive mixtures with liquid oxygen; forms shock sensitive explosive products upon reaction with sodium or potassium; forms an explosive complex with copper powder and copper (II) perchlorate and water; ignites on contact with cesium oxide and water; ignites on warming with iodine heptafluoride; explosive reaction with iron (III) oxide between 0°C and 150°C; reacts exothermically with lithium and water, sodium and ammonia, and potassium and oxygen; mixture of liquid carbon monoxide with liquid dinitrogen oxide is a rocket propellant combination; stop flow of gas if possible, and use water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, weakness of limbs, confusion, nausea, unconsciousness, death); skin contact (liquid will cause frostbite).

**FIRST AID:** liquid will cause frostbite; flush affected areas with large amounts of water; if vapor is inhaled, provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLO 600mg/m<sup>3</sup>/10M; inhalation-human LCLo 5000 ppm/5M; inhalation-man LCLo 4000 ppm/30M; inhalation-man TCLO 650 ppm/45M; toxic effect: central nervous system, blood.

**ACUTE HEALTH RISKS:** headache; dizziness; mental dullness; weakness; sleepiness; nausea; vomiting; loss of muscular control; increased then decreased pulse and respiratory rates; collapse; hallucinations; methemoglobinemia-carboxhemoglobinemia; unconsciousness; death by asphyxiation.

**CHRONIC HEALTH RISKS:** auditory disturbances; contraction of visual fields; glycosuria; heart irregularities; angina; cerebral congestion; cerebral edema; long-lasting mental or nervous damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm; OSHA PEL TWA 50 ppm (55 mg/m<sup>3</sup>); OSHA PEL CL 200 ppm; NIOSH REL TWA 35 ppm (40 mg/m<sup>3</sup>); NIOSH REL CL 200 ppm (229 mg/m<sup>3</sup>); IDLH 1200ppm.

**PERSONAL PROTECTION:** wear rubber overclothing, including chemical-resistant rubber gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; stop flow of gas if possible; if source of leak cannot be stopped, release to disperse gas; with cryogenic liquids, evacuate area and notify air and fire authority; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** pipe gas into incinerator and allow it to burn away; dissolve liquid in a more flammable solvent and atomize large amounts in a suitable combustion chamber; store in a cool, dry, well-ventilated location; use steel cylinders to store

pressurized gas; store cryogenic liquid in refrigerated tanks; keep away from strong oxidizers and halogen compounds.

**REGULATORY INFORMATION:** CA1; A1; CAL; DOT hazard class/division (2.3); labels (poison gas, flammable gas).

**OTHER COMMENTS:** used as a reducing agent in metallurgical operations, especially in the Mond process for the recovery of nickel; used in the Fischer-Tropsch processes in the organic synthesis of petroleum-type products and in the oxo reaction; used in the manufacture of metal carbonyls and in the manufacture of zinc white pigments.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 14.

### **CARBON TETRACHLORIDE (CCl<sub>4</sub>, 153.81)**

**CAS/DOT IDENTIFICATION #:** 56-23-5/UN1846

**SYNONYMS:** carbon chloride, carbon tet, freon<sup>®</sup>-10, halon<sup>®</sup>-104, tetrachloromethane.

**PHYSICAL PROPERTIES :** colorless, clear, heavy liquid; ether like odor; soluble in acetone and naphtha; miscible with alcohol, benzene, chloroform, ether, carbon disulfide, petroleum ether, and most fixed and nonvolatile oils; insoluble in water; MP (-23°C, -9°F); BP (77°C, 170°F); DN (1.5940 g/mL at 20°C); LSG (1.59); ST (270 dynes/cm); VS (1.329 cP at 0°C, 0.969 cP at 20°C); HV (8271.5 gcal/gmol); VD (5.31); VP (91.3 mmHg at 20°C); OT (>10ppm).

**CHEMICAL PROPERTIES:** generally inert; attacks some forms of plastics, rubber and coatings; reacts vigorously with sodium, potassium, magnesium, fluorine, and aluminum; HC (37.3 kcal/gmol at 20°C).

**EXPLOSION and FIRE CONCERNS:** noncombustible; non-explosive; NFPA rating Health 3, Flammability 0, Reactivity 0; vigorous exothermic reaction with allyl alcohol; forms impact-sensitive explosive mixtures with particulates of many metals; explosive mixtures with ethylene; violent or explosive reactions on contact with fluorine; potentially explosive reaction on contact with boranes; potentially dangerous reaction with dimethyl formamide; causes explosion when used as a fire extinguisher on wax and uranium fires; incompatible with aluminum trichloride, dibenzol peroxide, and potassium-tert-butoxide; decomposition emits toxic fumes of Cl and phosgene; use water spray or extinguishing agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin); skin absorption (nausea, dizziness, vomiting and drowsiness).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 1000ppm; inhalation-human LCLo 5pph/5M; inhalation-human TCLo 45ppm/3D; toxic effects: central nervous system, gastrointestinal tract; inhalation-human TCLo 317ppm/30M; toxic effect: gastrointestinal tract; inhalation-human 20ppm; toxic effect: gastrointestinal tract; oral-man TDLo 1700mg/kg; toxic effects: central nervous system, pulmonary system, gastrointestinal tract; oral-man LDLo 429mg/kg; toxic effects: central nervous system, pulmonary system, gastrointestinal tract; unknown-man LDLo 93mg/kg; oral-woman TDLo 1800 mg/kg; toxic effects: eye, central nervous system; EPA Cancer Risk Level (1 in a million excess lifetime risk)  $7 \times 10^{-5}$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; headache; dizziness; nausea; vomiting; stomach pains; dark urine; jaundice; liver damage; kidney damage; pulmonary edema; central nervous system depression.

**CHRONIC HEALTH RISKS:** cirrhosis of the liver; possible liver cancer; gastrointestinal effects; acute nephrosis; pupillary constriction; neurological changes; antipsychotic effect tremors; anorexia; coma.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5ppm; ACGIH TLV STEL 30ppm(skin); OSHA PEL TWA 10ppm; NIOSH REL TWA 12.6mg/m<sup>3</sup>; IDLH 200ppm.

**PERSONAL PROTECTION:** wear special protective clothing and rubber gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible with materials such as dry earth or sand; isolate material for proper disposal.

**DISPOSAL AND STORAGE METHODS:** do not burn, since hydrochloric acid will form; use steam stripping and other recover techniques; keep tightly closed in a cool, dry place; separate from alkali metals.

**REGULATORY INFORMATION :** CA2; S1; S32; S50-a; S61; S62; S10; F2; R1; R2-23; R3; R4; R5; R7; R8; R9; D waste #(D019); U waste # (U211); Reportable Quantity (RQ): 10lbs. (4.54 kg); Sf1; Sf3; CW1; CW2; CW3; CW4; CW5; A1; A2; CAL; DOT hazard class/division (6.1); labels (poisonous material).

**OTHER COMMENTS:** used in the formulation of gasoline additives; used in the metal degreasing industry; used as a chemical intermediate for fluorocarbons, pesticides and tetrabromomethane..

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 11; 12; 13; 14.

**CELLULOSE ((C<sub>6</sub>H<sub>10</sub>O<sub>5</sub>)<sub>n</sub>, 160,000-560,000)**

**CAS/DOT IDENTIFICATION #:** 9004-34-6/none

**SYNONYMS:** β-amylase, α-cellulose, cellulose crystalline, flour cellulose, hydroxycellulose, pyrocellulose.

**PHYSICAL PROPERTIES :** fine white substance; consists of crystalline areas imbedded in amorphous areas; odorless; tasteless; practically insoluble in water and most organic solvents; will dissolve in concentrated solution of zinc chloride; dissolved by ammoniacal copper hydroxide solution and also by caustic alkali with carbon disulfide; MP (260-270°C, 500-518°F); BP (decomposes); DN (1.50g/cm<sup>3</sup>); Bulk DN (0.3g/cm<sup>3</sup>); SG (1.27-1.61); VD (NA); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with water to form an adhesive form of silica; slowly decomposed by water; can react vigorously with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HF (NA).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 0, Flammability 1, Reactivity 0; not considered to be a fire hazard; remote possibility of a dust explosion exists if mixed with air in the proper proportions (similar to flour or starch); fires have been known to occur in warehouses in which telephone books were stored, due to heat buildup

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in the paper caused by microbial activity and self-sustaining oxidation; incompatible with water, bromine pentafluoride, sodium nitrate, fluorine, and strong oxidizers; carbon dioxide and carbon monoxide may form when heated to decomposition; use any means suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (no adverse health effects expected); skin/eye contact (no adverse health effects expected); ingested (may cause gastrointestinal upset).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if large amounts were swallowed, drink large amounts of water and get medical advice; in case of inhalation, first aid measures are usually not required.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and mucous membranes; large doses may cause gastrointestinal upset; no other adverse effects expected.

**CHRONIC HEALTH RISKS:** no information found concerning chronic health risks in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>, 5mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; safety glasses are recommended; not expected to require personal respirator usage; dilution ventilation is a satisfactory health hazard control for this substance; a local exhaust system should be considered if conditions of use create discomfort to the worker.

**SPILL CLEAN-UP:** sweep up spills and containerize for reclamation or disposal; use vacuuming or wet sweeping to avoid dust dispersal.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for reclamation may be delivered to an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements;; store in a cool, dry area with adequate ventilation; protect against physical damage; keep in tightly closed containers.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** cellulose is the fundamental constituent of all vegetable tissues (wood, cotton, flax, grass, etc.); most important uses of cellulose are bulk woods, paper (most of which is made from wood pulp), and cotton products; basic material also for cellulose acetate, methylcellulose, the nitrated product (nitrocellulose), and rayon and cellophane (from cellulose xanthate); basis of many plastics, fibers, lacquers, coatings, explosives, and emulsion stabilizers; also used in chromatography and as an ion exchange material; specialized uses include medical equipment (artificial kidney), non-woven fabrics, insulation, soundproofing, and sausage casings; also used in food industry as a stabilizer, texturizer, and thickener.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

**CHLORDANE (C<sub>10</sub>H<sub>6</sub>Cl<sub>8</sub>, 409.76)**

**CAS/DOT IDENTIFICATION #:** 57-74-9/UN2762

**SYNONYMS:** chlorindan, chlor kil, octachlorodihydrodicyclopentadiene; 1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane.

**PHYSICAL PROPERTIES :** viscous liquid; colorless to amber-colored; pungent chlorine-like odor; infinitely soluble in kerosene and many organic solvents; not soluble in water; MP (-116°C, -176.8°F); BP (175°C, 347°F at 2mmHg); DN (1.6 g/cm<sup>3</sup> at 25°C); LSG (1.6 at 77°F); VS (100 ssu at 38°C); VD (3.9); VP (0.00001 mmHg at 25°C).

**CHEMICAL PROPERTIES:** very stable; will not polymerize; attacks plastics, rubber, and coatings; reacts vigorously with strong oxidizers and alkaline reagents; decomposes in weak alkalis; produces hydrochloric acid upon decomposition; FP (-12°C, 10°F); LFL/UFL (1.1%, 6.7°C).

**EXPLOSION and FIRE CONCERNS:** dangerous fire hazard; NFPA rating (not available); emits toxic fumes of Cl<sup>-</sup> when heated to decomposition; incompatible with reducing agents; use carbon dioxide, foam, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (blurred vision, coughing, delirium, confusion, and ataxia).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 29mg/kg; toxic effect: liver; skin-human LDLo 428mg/kg; toxic effect: central nervous system; sce-human lymphocyte 10μmol/L; oral-man TDLo 3071μg/kg; unreported-man LDLo 118mg/kg; oral-woman LDLo 120μg/kg; toxic effects: central nervous system, gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, nose, and throat; abdominal pain; nausea; vomiting; dizziness; convulsions; labored breathing; tachycardia; seizures with frothing at the mouth; unconsciousness.

**CHRONIC HEALTH RISKS:** liver and kidney damage; anorexia; loss of weight; hepatocellular carcinomas.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.5mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.5mg/m<sup>3</sup> (skin); IDLH 100mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing and rubber gloves; wear chemical safety goggles; wear face mask with organic vapor canister.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; ventilate area; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; atomize large amounts in a suitable combustion chamber; outside storage preferred; inside storage should be in a standard flammable liquids storage room or cabinet.

**REGULATORY INFORMATION :** CA2; S1; S24; S32; S50-a; S61; S62; F4; R4; R5; R7; R8; D waste # (D020); U Waste # (U036); Reportable Quantity (RQ): 11b (0.454 kg); Sf1; Sf2; Sf3; CW1; CW2; CW5; A1; CAL.

**OTHER COMMENTS:** used as a pesticide and insecticide; used as a fumigant; used for household and veterinary uses.

**KEY REFERENCES:** 4; 5; 6; 7; 9; 12; 13.

**CHLORINATED CAMPHENE (C<sub>10</sub>H<sub>10</sub>Cl<sub>8</sub>, 413.80)**

CAS/DOT IDENTIFICATION #: 8001-35-2/UN2761

SYNONYMS: chlorocamphene, octachlorocamphene, polychlorocamphene, toxaphene.

**PHYSICAL PROPERTIES** : yellow-to-amber waxy solid; pleasant, piney odor; mild chlorine-and camphor-like odor; mild, turpentine-like odor; soluble in alcohol, acetone, and hexane; freely soluble in aromatic hydrocarbons; readily soluble in organic solvents; almost insoluble in water; MP (65-90°C, 149-194°F); DN (1.65 g/cm<sup>3</sup> at 25°C); SG (1.65); VP (0.2 to 0.4 mmHg at 20°C); OT (0.14ppm).

**CHEMICAL PROPERTIES**: non-corrosive in the absence of moisture; dehydrochlorinates in presence of alkali, in prolonged exposure to sunlight, and at temperatures above 155°C; dehydrochlorinated by certain catalysts such as iron; reacts vigorously with strong oxidizing agents; reacts with bases; slightly corrosive to metals under moist conditions.

**EXPLOSION and FIRE CONCERNS**: nonflammable; NFPA rating Health 3, Flammability 1, Reactivity 0; decomposition emits toxic gases and vapors, such as hydrogen chloride and carbon monoxide; decomposes on heating; incompatible with strong oxidizers; use agent suitable for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (nausea, confusion, agitation); skin absorption (vomiting, tremors, convulsions).

**FIRST AID**: wash eyes immediately with large amounts of water; flush skin with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA**: sce-human lymphocyte 10µmol/L; oral-human LDLo 28mg/kg; toxic effect: central nervous system; skin-human TDLo 657 mg/kg; toxic effect: skin; oral-man LDLo 29mg/kg; unreported-man LDLo 44mg/kg; EPA Cancer Risk Level (1 in a million excess lifetime risk): 3.0 x 10<sup>-6</sup> mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS**: skin irritation; respiratory failure; central nervous system stimulation; seizures; convulsions; vomiting; nausea; diarrhea; coma; death.

**CHRONIC HEALTH RISKS**: temporary deafness; confusion; loss of appetite; loss of weight; reversible respiratory toxicity.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 0.5mg/m<sup>3</sup>; ACGIH TLV STEL 1mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.5mg/m<sup>3</sup>; OSHA PEL STEL 1mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.5mg/m<sup>3</sup>; IDLH 200mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: use impervious clothing, gloves, and face shields; use compressed air/oxygen apparatus.

**SPILL CLEAN-UP**: absorb as much as possible with materials such as activated carbon or dry earth; polyolefin or polyisobutylene fibers may also be used for cleanup.

**DISPOSAL AND STORAGE METHODS**: absorb in dry earth, sodium bicarbonate, or sand-soda ash mixture; cautiously ignite small amounts in open areas; dissolve in flammable solvent and atomize large amounts in a suitable incinerator equipped with afterburner and scrubber; outdoor storage preferred; keep container closed; isolate from certain metals such as iron; keep away from moisture.

**REGULATORY INFORMATION** : Sfl; A1; Reportable Quantity (RQ): 1lb (0.454 kg).

**OTHER COMMENTS:** used for pest control in livestock and poultry; used to control pests on cotton crops, wheat, corn, and soybeans; banned as a pesticide in 1982 by EPA.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13; 14.

### **CHLORINATED DIPENYL OXIDE (C<sub>12</sub>H<sub>4</sub>Cl<sub>6</sub>O, 376.86)**

**CAS/DOT IDENTIFICATION #:** 55720-99-5/none

**SYNONYMS:** benzene, 1,1'-oxybis, hexachloro, chlorinated diphenyl ether, hexachlorodiphenyl ether, hexachlorodiphenyl oxide, hexachlorophenyl ether, trichlorodiphenyl ether, trichlorodiphenyl oxide.

**PHYSICAL PROPERTIES :** white or yellowish waxy solid material or very viscous liquid; mild chemical odor; moderately soluble in paraffins, aromatics, halogenated solvents, esters, and ketones; sparingly soluble in alcohols; slightly soluble in water; MP (NA); BP (230 - 260°C, 446-500°F at 8 mmHg); DN (1.60 g/mL at 20°C); LSG (1.60); VD (13.0); VP (< 0.00006 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; stable in presence of ordinary organic bases, inorganic bases, alkaline oxidizing agents, and dilute acids; reacts with acid oxidizing agents, including chlorine, bromine, and fluorine; FP (NA); LFL/UFL (NA); AT (620°C, 1148°F).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid or liquid; exposure to heat or flame will enhance combustibility; NFPA rating Health 2, Flammability 1, Reactivity 1; contact with strong oxidizers (such as bromine, chlorine, and fluorine) will result in violent reactions; hydrochloric acid fumes and other chlorinated decomposition products may be released in a fire; use dry chemical, carbon dioxide, water spray, fog, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation/ingestion (cumulative liver damage); contact (acne-form dermatitis, burns to skin and eyes).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen if breathing is difficult; provide artificial respiration if breathing has stopped; if this chemical has been swallowed, seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD50/LC50 information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** headache; dizziness; nausea; vomiting; minor erythema; may cause burns to the skin and eyes.

**CHRONIC HEALTH RISKS:** repeated or prolonged exposure can cause an acne-like skin rash (chloracne); long-term exposure may damage the liver; this chemical has not been tested for its ability to cause cancer in animals or to adversely affect reproduction.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>; ACGIH TLV STEL 2 mg/m<sup>3</sup>; OSHA PEL TWA 0.5 mg/m<sup>3</sup>; NIOSH REL TWA 0.5 mg/m<sup>3</sup>; IDLH 5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including rubber boots, solvent-resistant gloves, lab coat, bib-type apron or coveralls; use chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where the potential for exposures is higher than 0.5 mg/m<sup>3</sup>; if the

possibility of exposures above 5 mg/m<sup>3</sup> exists, use positive pressure self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; if in solid form, cautiously collect spilled material by vacuuming with an appropriate high-efficiency filtration system, and deposit in sealed containers for disposal in an approved facility; absorb liquids in inert materials, such as dry earth, sand or vermiculite, and deposit in chemical waste containers.

**DISPOSAL AND STORAGE METHODS:** contain and dispose of chlorinated diphenyl oxide as a hazardous waste; disposal should be in accordance with federal, state, and local environmental regulations; store in tightly closed containers in a cool, well-ventilated area; keep away from any area where the fire hazard may be acute; store to avoid contact with strong oxidizers.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none); labels (none required).

**OTHER COMMENTS:** Chlorinated diphenyl oxide may be used as a chemical intermediate in the preparation of other chemicals; has also been used in the dry cleaning industry, in particular, as a component of dry cleaning solvents. Chlorinated diphenyl oxide is on the Hazardous Substance List because it is cited by ACGIH and regulated by OSHA.

**KEY REFERENCES:** 4; 5; 6; 15; 18.

## CHLORINE (Cl<sub>2</sub>, 70.9)

**CAS/DOT IDENTIFICATION #:** 7782-50-5/UN1017

**SYNONYMS:** bertholite, molecular chlorine.

**PHYSICAL PROPERTIES :** greenish-yellow, diatomic gas; clear, amber liquid; irritating, bleach-like choking odor; nonmetallic halogen element; soluble in alkali; soluble in chlorides and alcohols; slightly soluble in cold water; MP (-101°C, -150°F); BP (-34.6°C, -30.3°F); LDN (1.47 g/mL at 0°C, 3.65 atm); LSG (1.57 at 34°C); ST (18.4 dynes/cm at 20°C); CP (8.11 cal/mol/°C at 25°C); VD (2.49); VP (5atm at 10.3°C, 6.8 atm at 20°C); OT(0.0020mg/L-water, 0.31 ppm-air); LP(7.86 atm at 25°C).

**CHEMICAL PROPERTIES:** elevated temperatures contribute to instability; combines readily with all elements except the rare gases (xenon excluded) and nitrogen; acts as an electron acceptor in forming complexes with many donor species; extremely strong oxidizing agent; reacts vigorously with organic materials, reducing agents, active metals, and ammonia; reacts with water to form corrosive, acidic solutions; attacks some forms of plastics, rubber, and coatings; FP (0°C, 32°F).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas, but strong oxidizer; NFPA rating Health 4, Flammability 0, Reactivity 0; reacts explosively with acetylene, ether, turpentine, ammonia, fuel gas, hydrogen, and finely divided metals; reacts violently with many alcohols; explodes on contact with molten aluminum, ammonia, benzene, bromine pentafluoride, diborane, and many others; combines with moisture to form reactive hydrogen chloride gas; use water spray or fog for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes, skin and nose); skin absorption (respiratory distress, excitement, restlessness, headache, nausea).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 2530mg/m<sup>3</sup>/30M; toxic effect: pulmonary system; inhalation-human LCLo 500ppm/5M; cyt-human lymphocyte 20ppm.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and mucous membranes; emphysema; coughing; pulmonary edema; headache; dizziness; nausea; vomiting; substernal pain; reduced oxygen in the blood; death.

**CHRONIC HEALTH RISKS:** changes in pulmonary function; dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5ppm (49mg/m<sup>3</sup>); STEL 1ppm; OSHA PEL TWA 0.5ppm; STEL 1ppm; NIOSH REL 0.5ppm/15M (1.45mg/m<sup>3</sup>); IDLH 10ppm.

**PERSONAL PROTECTION:** wear impervious clothing; wear chemical safety face shield and rubber gloves; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; apply vapor suppression foam to limit vaporization from liquid release; if in liquid form, absorb as much as possible with materials such as dry earth or sand; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** reduce with bisulfite or a ferrous salt; add soda ash or dilute hydrochloric acid to neutralize; route to sewage plant; absorb in dry earth or sand, and place in a sanitary landfill; store in a cool, dry well-ventilated location; separate from combustible, organic, or easily oxidizable materials; outside storage preferred.

**REGULATORY INFORMATION :** CA2; S3; R6; Reportable Quantity (RQ): 10lbs (4.54 kg); Sf1; Sf2; Sf3; CW2; T225-a; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, corrosive).

**OTHER COMMENTS:** used in the manufacture of carbon tetrachloride, metallic chlorides, chloroacetic acid, chlorobenzene, and chloroform; used in the manufacture of plastics, anti-freeze, refrigerants, and anti-knock compounds; major use is in the purification of water.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14.

## **CHLORINE DIOXIDE (ClO<sub>2</sub>, 67.45)**

**CAS/DOT IDENTIFICATION #:** 10049-04-4/NA

**SYNONYMS:** chlorine oxide, chlorine (IV) oxide, chlorine peroxide, chloroperoxyl.

**PHYSICAL PROPERTIES :** yellow to red gas at room temperature; solid is a yellowish-red crystalline mass; liquid is a reddish-brown; unpleasant odor similar to chlorine and nitric acid; soluble in alkaline and sulfuric acid solution; insoluble in water; MP (-59°C, -74°F); BP(11°C, 52°F); DN(1.642 g/mL liquid at 0°C); LSG (1.6); CP(42.0 J/K-mol gas at 25°C); HV (30 kJ/mol at 284K); VD(2.33); VP(>1 atm at 20°C).

**CHEMICAL PROPERTIES:** flammable gas/combustible liquid; unstable in light; stable in dark if pure; chlorides catalyze its decomposition even in dark; very reactive; strong oxidizer; hydrolyzes slightly in water to form chlorous and chloric acids; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (102.5 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** unstable in light; NFPA rating (not available); easily detonated by sunlight, heat, contact with mercury, or carbon monoxide, when in excess concentration of 10% at atmospheric pressure; explodes when heated or by reaction with organic materials; a powerful oxidizer; explodes on mixing with butadiene, ethane, ethylene, methane, propane, difluoramine, and trifluoramine; explodes on contact with mercury, potassium hydroxide, and phosphorus pentachloride + chlorine; ignites or explodes on contact with non-metals, such as phosphorus, sulfur, and sugar; reacts violently with fluorine and difluoroamine; mixtures with hydrogen explode with sparking or contact with platinum; reacts with water or steam to produce toxic and corrosive fumes of hydrogen chloride; heating to decomposition emits toxic fumes of Cl<sup>-</sup>; use flooding quantities of water or agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, wheezing, bronchitis, pulmonary edema, irritation of eyes, nose and throat).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** a concentration of 5ppm is irritating; 19 ppm of the gas is more than sufficient to cause the death of a human being (time of exposure not specified).

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and throat; coughing, wheezing; bronchitis; pulmonary edema; very irritating to skin and mucous membranes; sneezing; copious salivation; restlessness; general excitement; respiratory distress; death from suffocation.

**CHRONIC HEALTH RISKS:** chronic bronchitis; may alter genetic material; reproductive effects; target organs: eyes, respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1ppm; ACGIH TLV STEL 0.3 ppm; OSHA PEL TWA 0.1ppm (0.3 mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.3 mg/m<sup>3</sup>) NIOSH REL STEL 0.3 ppm (0.9 mg/m<sup>3</sup>); IDLH 5 ppm.

**PERSONAL PROTECTION:** wear rubber over-clothing, including gloves; use self-contained breathing apparatus of materials not susceptible to chlorine attack; wear chemical safety goggles.

**SPILL CLEAN-UP:** ventilate area of spill; if in gaseous form, stop flow of gas if possible; if leak cannot be stopped in place, allow to empty in a safe place in open air; if in liquid form, allow to evaporate while providing adequate ventilation; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; store in a cool area; maintain adequate ventilation along floor; separate from combustible and reducing substances.

**REGULATORY INFORMATION:** S3; Sf3; A1; A5; CAL; DOT hazard class/division (forbidden).

**OTHER COMMENTS:** used in bleaching cellulose, flour, leather, oils, textiles, and beeswax; useful in the purification of water; used to control taste and odor of water; used in the purification of swimming pool water and as a wastewater disinfecting agent; also used in the manufacture of chlorine salts; a bactericide, antiseptic and deodorizer.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 11; 14.

**CHLORINE TRIFLUORIDE (ClF<sub>3</sub>, 92.45)**

CAS/DOT IDENTIFICATION #: 7790-91-2/UN1749

SYNONYMS: chlorine fluoride, chlorotrifluoride.

**PHYSICAL PROPERTIES** : colorless gas; greenish-yellow liquid below 53°F; solid is white; sweet, suffocating odor, somewhat similar to chlorine; MP (-76.34°C, -105.41°F); BP (11.75°C, 53.15°F); DN (1.825 g/mL liquid at 53°F, 3.14 g/L gas, 2.530 g/cm<sup>3</sup> solid at 153K); SG (1.77, liquid at 53°F); ST (26.6 dynes/cm at 273K); VS (0.448 mPa-s liquid at 290K); HV (27.50 kJ/mol at 284.90K); VD (3.21); VP (10 mmHg at -71.8°C, 400 mmHg at -4.9°C, 760 mmHg at 11.5°C).

**CHEMICAL PROPERTIES**: stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; a powerful oxidant; reacts with water to form chlorine and hydrofluoric acid; corrosive; attacks quartz if traces of moisture are present; decomposes in cold and hot water; reacts with organic matter, glass, asbestos, sand, acids, alkalis, halogens, salts chlorofluorocarbons, metal oxides, and many other materials; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF(164.5 kJ/mol at 25°C); H<sub>f</sub> (7.60 kJ/mol at 196.8K); T<sub>c</sub> (154.5°C, 310°F).

**EXPLOSION and FIRE CONCERNS**: nonflammable gas; noncombustible liquid, but can ignite spontaneously on contact with organic or silicon containing materials; NFPA rating Health 4, Flammability 0, Reactivity 3; violently hydrolyzed by water, forming chlorine and hydrofluoric acid; violent reaction with chromic anhydride, with evolution of brown fumes; produces a violent reaction without flame in presence of arsenic trioxide, lanthanum oxide, bismuth trioxide, phosphorus pentoxide or stannic oxides; a violent reaction occurs when in contact with rubber; shock-sensitive explosive mixtures are formed with highly chlorinated compounds (e.g., carbon tetrachloride) and nitroaryl compounds (e.g., trinitrotoluene); gas will ignite on exposure to finely divided boron, tetraboron carbide, and boron-aluminum mixtures; interaction with chromium trioxide is incandescent; combinations of liquid with several halocarbons, except perfluorohexane, exploded immediately at all temperatures between 25°C and -70°C; mixtures of the liquid with several hydrocarbons exploded immediately at all temperatures ranging from 25°C to -70°C; extremely violent reaction with ruthenium metal at ambient temperatures, resulting in the formation of the adduct chlorine trifluoride-ruthenium pentafluoride.; reaction with acetic acid, benzene, and diethyl ether is very violent, sometimes explosive; causes an explosive reaction with ammonia, carbon monoxide, hydrogen sulfide, sulfur dioxide or hydrogen; contact with dilute vapors will cause glass wool and organic matter to burst into flames; decomposes above 220°C (428°F) and may explode container; in the vapor phase, decomposes into a variety of substances (e.g., chlorine, fluorine, hydrogen, fluoride, and chlorine dioxide); use of dry chemical or carbon dioxide is preferred for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (coughing, shortness of breath, build-up of fluid in lungs, irritates eyes, skin and respiratory system); contact (severe eye and skin burns, sneezing, runny nose).

**FIRST AID**: immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, seek immediate medical attention.

**HUMAN TOXICITY DATA**: inhalation-human LCLo 50 ppm; hazard of exposure to chlorine trifluoride in atmosphere is as great as that of chlorine.

**ACUTE HEALTH RISKS:** can severely burn the skin; severe eye burns, leading to permanent damage; severe irritation of nose, throat, and lungs; coughing; shortness of breath; pulmonary edema; can cause death.

**CHRONIC HEALTH RISKS:** can cause deep penetrating burns on contact with body (effect may be delayed and progressive); repeated exposure can cause sneezing and runny nose; has not been tested for its ability to cause cancer in animals or to adversely affect reproduction.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 0.1 ppm (0.38 mg/m<sup>3</sup>); OSHA PEL CL 0.1 ppm (0.4 mg/m<sup>3</sup>); NIOSH REL CL 0.1 ppm (0.4 mg/m<sup>3</sup>); IDLH 20 ppm.

**PERSONAL PROTECTION:** wear appropriate personal protective clothing made of glass fiber and Teflon; neoprene gloves are preferred; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; wear positive pressure self-contained breathing apparatus; splash-proof safety goggles should be worn when working with liquid; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; if in gaseous form, stop flow of gas; if source of leak is a cylinder, cautiously remove leaking cylinder to a safe location in open air, and allow the cylinder to empty; if in liquid form allow substance to evaporate while providing adequate ventilation.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in accordance with federal, state, and local regulations; criteria for land treatment or sanitary landfill disposal practices are subject to significant revision; store in a cool, dry location; use only with adequate ventilation; outside storage is preferred; keep cylinders restrained; separate from water, sand, glass, asbestos, silicon-containing compounds, organic matter, acids, alkalies, halogens, metal oxides, salts, and chlorofluorocarbons.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, oxidizer, corrosive).

**OTHER COMMENTS:** used as a fluorinating agent; applications in nuclear reactor fuel processing; has also been used to ignite and propel rockets; inhibits pyrolysis for fluorocarbon polymers; utilized in the processing of nuclear fuels to convert uranium to gaseous uranium hexafluoride; useful as a low temperature etchant for single crystalline silicon and in cutting oil well tubes; was used by Germany as an incendiary gas during World War II; most of the product is used in the processing of nuclear fuels.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14; 15; 16; 18.

### **CHLOROACETALDEHYDE (ClCH<sub>2</sub>CHO, 78.50)**

**CAS/DOT IDENTIFICATION #:** 107-20-0/UN2232

**SYNONYMS:** chloroacetaldehyde monomer, 2-chloroacetaldehyde, chloroaldehyde, 2-chloroethanal, 2-chloro-1-ethanal, monochloroacetaldehyde.

**PHYSICAL PROPERTIES :** clear, colorless liquid; very sharp, pungent odor; typically found as a 40% aqueous solution; miscible in all proportions with water; soluble in water, acetone, methanol, and ether; MP (-16.3°C, 2.7°F); BP (85-86°C, 185-187°F at 760 mmHg); DN (1.19 g/mL at 25°C); LSG (1.19); VD (2.7); VP (100 mmHg at 20°C); OT (3.0 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; at concentrations greater than 50% in water, it forms an insoluble hemihydrate; reacts with oxidizing materials; forms a water-insoluble polymer in storage, especially in presence of small amounts of acid; FP (87.7°C, 190°F); LFL/UFL (unknown); AT (88°C, 190.4°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating (not rated); moderate fire potential, when exposed to heat or flame; contact with oxidizing materials and acids may cause fires or explosions; reacts with water to form a hydrate with the evolution of some heat; anhydrous substance will polymerize on standing, but reverts to the monomer on distillation; toxic gases and vapors (such as carbon dioxide and Cl<sup>-</sup>) may be released in a fire; use water, alcohol foam, carbon dioxide or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, shortness of breath, build-up of fluid in lungs, wheezing, chest tightness, irritates eyes, skin and respiratory system); skin absorption (respiratory system sensitization, skin sensitization, narcotic effects); contact (destroys tissues of mucous membranes, chemical burns to the skin and eyes, scarring, skin allergies).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, induce vomiting or administer syrup of ipecac; seek immediate medical attention.

**HUMAN TOXICITY DATA:** dna damage-human lymphocyte 100µmol/L; mutations in mammalian somatic cells-human lymphocyte 16µmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and mucous membranes; can cause severe skin burns; may severely burn the eyes; irritation to nose, throat, and lungs; coughing; shortness of breath; pulmonary edema; respiratory system sensitization; narcosis; coma.

**CHRONIC HEALTH RISKS:** corrosive destruction and degradation of lipids and membrane structures; prolonged exposure causes tissue destruction, chemical burns, and residual scarring; may cause permanent eye damage; skin and respiratory sensitization; may cause a skin allergy; may cause an asthma-like allergy; can cause asthma attacks with shortness of breath, wheezing, cough, and chest tightness; may cause mutations (genetic changes in living cells).

**EXPOSURE GUIDELINES:** ACGIH TLV CL 1 ppm (3.2 mg/m<sup>3</sup>); OSHA PEL CL 1 ppm (3 mg/m<sup>3</sup>); NIOSH REL CL 1 ppm (3 mg/m<sup>3</sup>); IDLH 45 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including rubber gloves and boots, rain hat, raincoat, and charcoal canister full face mask; splash-proof safety goggles are recommended; enclose operations and use local exhaust ventilation at site of release; appropriate respirators are needed in areas where exposure would exceed 1 ppm; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash bath and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb small quantities on paper towels, and evaporate in a fume hood; sufficient length of time should be allowed for evaporating vapors to completely clear the hood dustwork; absorb large quantities of liquid with inert materials (e.g., dry earth, sand, vermiculite), and deposit in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; atomize large amounts in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, well ventilated location away from heat and open flames; should not come into contact with water because heat may be evolved as

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chloroacetic acid is formed; store in tightly closed containers; avoid contact with acids and oxidizers (such as perchlorate, peroxides, chlorates, nitrates, and permanganates.)

**REGULATORY INFORMATION:** R4; P waste # (P023); Reportable Quantity (RQ): 1000 lbs (454 kg); Sfl; A1; CAL; DOT hazard class/division (6.1); label (poison).

**OTHER COMMENTS:** used in the manufacture of 2-aminothiazole; used in the control of algae, bacteria, and fungi in water; utilized in the facilitation of removal of bark from tree trunks; has also been used as a spinning solution of poly B-alanine; useful in dentistry.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14; 15; 16.

### a-CHLOROACETOPHENONE (C<sub>6</sub>H<sub>5</sub>COCH<sub>2</sub>Cl, 154.60)

**CAS/DOT IDENTIFICATION #:** 532-27-4/UN1697

**SYNONYMS:** 2-chloracetophenone, chloromethyl phenyl ketone, mace<sup>®</sup>, phenacyl chloride, phenyl chloromethyl ketone; tear gas.

**PHYSICAL PROPERTIES :** colorless to gray crystalline solid; odor resembling apple blossoms; freely soluble in alcohol, ether, and benzene; practically insoluble in water; MP (56.5°C, 134°F); BP (244-245°C, 471-473°F); DN (1.324 g/cm<sup>3</sup> at 15°C); SG (1.32); VP (5.4 x 10<sup>-3</sup> mmHg at 20°C); OT(0.035 ppm).

**CHEMICAL PROPERTIES:** stable; will not polymerize; reacts vigorously with water, steam, strong oxidizers, and alkali; FP (118°C, 244°F); HC (-9340 Btu/lb, -5190cal/g, -217 x 10<sup>5</sup> J/kg).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 2, Flammability 1, Reactivity 0; combustion will produce carbon dioxide, carbon monoxide, and hydrogen chloride; emits toxic decomposition and hydrolysis products when in contact with steam; capable of creating dust explosions; incompatible with strong oxidizing agents, water, and alkali; when heated to decomposition, emits toxic fumes of Cl<sup>-</sup>; use dry chemical, water spray, mist, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (tearing and burning of eyes, difficulty in breathing); skin absorption (irritation of skin, intense irritation of eyes); ingestion (agitation, contraction of pupils, loss of reflexes).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 159 mg/m<sup>3</sup>/20M; inhalation-human TLCo 93mg/m<sup>3</sup>/3M; toxic effect: eye; inhalation-human TCLo 20mg/m<sup>3</sup>; toxic effect: eye.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; lacrimation (discharge of tears); blurred vision; corneal damage; dyspnea (breathing difficulty); first, second, and third degree burns; contraction of pupils; loss of reflexes; agitation; coma.

**CHRONIC HEALTH RISKS:** acute pulmonary edema; no other information available for humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05ppm (49mg/m<sup>3</sup>); OSHA PEL TWA 0.05ppm (0.3mg/m<sup>3</sup>); NIOSH REL TWA 0.05ppm(0.3mg/m<sup>3</sup>); IDLH 15mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and rubber gloves; wear chemical safety goggles; wear self-contained breathing apparatus..

**SPILL CLEAN-UP:** sweep onto paper or other suitable material and cautiously ignite amounts in open areas; dissolve in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber; ventilate area of spill.

**DISPOSAL AND STORAGE METHODS:** pour onto sodium bicarbonate or sand-soda ash mixture and dump in closed incinerator with afterburner; dissolve in flammable solvent and spray in incinerator equipped with afterburner and alkali scrubber; storage should be in tightly closed containers; keep from contact with water, alkali, and oxidizing materials.

**REGULATORY INFORMATION :** T30-e10; T120-d10; Reportable Quantity (RQ): 100lbs (45.4 kg); DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of tear gas and chemical mace; used as a pharmaceutical intermediate; former use as an alcohol denaturant.

**KEY REFERENCES:** 2; 4; 5; 6; 7; 11; 12; 13; 14.

## CHLOROBENZENE (C<sub>6</sub>H<sub>5</sub>Cl, 112.56)

**CAS/DOT IDENTIFICATION #:** 108-90-7/UN1134

**SYNONYMS:** benzene chloride, chlorobenzol, monochlorobenzene, phenyl chloride.

**PHYSICAL PROPERTIES :** clear, colorless liquid; almond-like odor; soluble in alcohol, ether, benzene, chloroform, and carbon disulfide; negligible solubility in water; miscible with nearly all organic solvents; MP (-45°C, -49°F); BP (132°C, 269°F); DN (1.058 g/mL at 20°C); LSG (1.11); ST (33 dynes/cm at 25°C); VS (0.790 cP at 70°F); CP (150.1 J/mol-K at 25°C); HV (75 cal/g, 3.14 x 10<sup>5</sup> J/kg); VD (3.9); VP (12mmHg at 25°C); OT(0.210 ppm).

**CHEMICAL PROPERTIES:** generally very stable; will not polymerize; will react vigorously with strong oxidizers; combustion by-products include phosgene and hydrogen chloride gases; FP (28°C, 84°F); LFL/UFL (1.3%, 9.6%); AT (592°C, 1099°F); HC (6700cal/g, 280x10<sup>5</sup>J/kg); HF (11.0 kJ/mol liquid at 25°C); H<sub>f</sub> (9.61 kJ/mol at -45.3°C).

**EXPLOSION and FIRE CONCERNS:** dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 0; reacts violently with silver perchlorate and dimethyl sulfoxide; forms explosive mixtures with powdered sodium or phosphorous trichloride and sodium; may cause fire on contact with strong oxidizers; vapors may flow to distant ignition sources and flash back; closed containers exposed to heat may explode; emits toxic gases such as hydrogen chloride, phosgene, carbon monoxide, and carbon dioxide, when heated to decomposition; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of eyes, skin and mucous membranes); ingestion (headache, nausea, vomiting, gastrointestinal irritation).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** clinical examination of workers exposed to chlorobenzene in the manufacture of polyvinyl chloride showed that some workers suffered from poisoning at concentrations in the atmosphere close to 50mg/m<sup>3</sup>.

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**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory tracts; rapid respiration; irregular pulse; gastrointestinal effects; nausea; vomiting; dizziness; headaches; drowsiness; unconsciousness; red urine.

**CHRONIC HEALTH RISKS:** central nervous system depression; lung damage; kidney damage; liver damage; blood disorders; bone marrow disease; glandular disorders; affects the formation of platelets which are necessary for blood clotting.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm (49mg/m<sup>3</sup>); OSHA PEL TWA 75ppm (350mg/m<sup>3</sup>); NIOSH REL TWA not established; IDLH 1000ppm..

**PERSONAL PROTECTION:** wear impervious clothing, boots, gloves, aprons, etc.; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; flush remaining chlorobenzene with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in a sanitary landfill; cautiously ignite small amounts in open areas; atomize large amounts in a suitable combustion chamber; outside storage preferred; inside storage should be in a standard flammable liquids storage room.

**REGULATORY INFORMATION :** CA2; S1; S10; R2-24; R3; R5; R8; R9; D waste # (D021); U waste # (U037); Reportable Quantity (RQ): 100lbs (45.4 kg); Sf1; Sf3; CW1; CW2; CW4; CW5; T30-e10; T120-d10; T766-38; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of dye stuffs, phenol, aniline, cumene, and chloronitrobenzenes; used in the textile, dry cleaning, and degreaser industries; used as a heat transfer medium..

**KEY REFERENCES:** 1; 2; 3; 4; 5; 6; 7; 8; 9; 11; 12; 13; 14; 15.

### **o-CHLOROBENZYLIDENE MALONONITRILE (C<sub>10</sub>H<sub>5</sub>ClN<sub>2</sub>, 188.62)**

**CAS/DOT IDENTIFICATION #:** 2698-41-1/none

**SYNONYMS:** o-chlorobenzal malononitrile, 2-chlorobenzal malononitrile, 2-chlorobenzylidene malononitrile, 2-chlorobmm, beta, beta-dicyano-o-chlorostyrene, propanedinitrile ((2-chlorophenyl)methylene).

**PHYSICAL PROPERTIES :** white crystalline solid; odor of pepper; insoluble in water; soluble in acetone, benzene, dioxane, methylene chloride, and ethyl acetate; MP (93-95°C, 199.4-203°F); BP (310-315°C, 590-599°F); DN (unknown); SG (unknown); VD (NA); VP (3.4 x 10<sup>-5</sup> mmHg at 20°C)

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react with strong oxidizers; FP (unknown); LFL/UFL (unknown); AT (unknown); HC (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating (not rated); incompatible with strong oxidizers; minimum explosive concentration (MEC) is 25 g/m<sup>3</sup>; heating to decomposition emits very toxic fumes of hydrogen chloride, nitrogen oxides and cyanides; in case of fire in the surroundings, all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, discharge of tears, cough, unspecified respiratory system effects, irritates eyes, skin and mucous membranes); skin and/or eye contact (skin redness, redness of eyelids, skin vesiculation, dermatitis); skin absorption (headache, hypersensitivity reactions, bronchospasm); ingestion (pneumonia, heart failure, hepatocellular damage).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if breathing has stopped, administer mouth-to-mouth resuscitation; in case of ingestion, seek immediate medical attention.

**HUMAN TOXICITY DATA:** inhalation-human  $\text{TCLo } 1500 \mu\text{g}/\text{m}^3/90\text{M}$ ; toxic effect: sense organs and special senses (nose, eye, ear, and taste)-conjunctiva irritation, lung, thorax, or respiration-cough, other changes; skin-human  $10\text{mg}/1\text{H}$ ; toxic effect: mild; eye-man  $624 \text{ng}$ ; toxic effect: not reported; eye-man  $5\text{mg}/\text{m}^3/20\text{S}$ ; toxic effect: severe.

**ACUTE HEALTH RISKS:** lacrimation; headache; contact burns to the eyes and skin; conjunctivitis; erythemic eyelids; bronchospasm; laryngospasm; hypersensitivity reaction; pulmonary edema; irritation of throat; cough; chest constriction; erythema (skin redness); vesiculation of skin; pneumonia; heart failure.

**CHRONIC HEALTH RISKS:** prolonged exposure may cause skin sensitization and dermatitis of the arms and neck; pneumonitis may result following prolonged exposure; persistent leukocytosis (white blood cell count  $20,000$  to  $30,000/\text{mm}^3$ ) with a predominance of lymphocytes on peripheral blood smear may develop.

**EXPOSURE GUIDELINES:** ACGIH TLV CL  $0.05 \text{ppm}$  ( $0.39 \text{mg}/\text{m}^3$ )(skin); OSHA PEL TWA  $0.05 \text{ppm}$  ( $0.4 \text{mg}/\text{m}^3$ ); NIOSH REL CL  $0.05 \text{ppm}$  ( $0.4 \text{mg}/\text{m}^3$ )(skin); IDLH  $2 \text{mg}/\text{m}^3$ ;

**PERSONAL PROTECTION:** wear appropriate personal protective clothing to prevent skin contact, including chemical-resistant gloves; wear dust-proof safety goggles to prevent eye contact; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper, place in a suitable container, and burn in a fume hood; dissolve large quantities in flammable solvent (such as alcohol) and burn in suitable combustion chamber equipped with afterburner and scrubber; spill area may be decontaminated by washing with a 5% solution of sodium hydroxide in 50/50 ethyl alcohol/water or by covering the spill with a 10% solution of sodium hydroxide in 50/50 isopropyl alcohol/water; after letting solution stand for 20 minutes, flush with copious amounts of water.

**DISPOSAL AND STORAGE METHODS:** prepare packages of material in paper or other flammable materials and burn in suitable combustion chamber equipped with appropriate effluent gas cleaning device; dissolve in flammable solvent (such as alcohol) and atomize in suitable combustion chamber equipped with afterburner and scrubber; may also be disposed of by mixing solid with 5 parts of 10% monoethanol amine solution in water containing 0.3% of nonionic detergent or by stirring 1 lb. of solid for 2 hours in 1 gallon of a 5-15% solution of sodium hydroxide in methyl alcohol, ethyl alcohol, or sodium hydroxide; store in a cool, dry location; use only with adequate ventilation; storage should be in tightly closed containers; separate from strong oxidizing materials; avoid heats, sparks, and open flame.

**REGULATORY INFORMATION: A1.**

**OTHER COMMENTS:** used primarily as a tear-gas and riot control agent; can be disseminated in burning grenades and weapon-fired projectiles, as an aerosol form the finely divided solid chemical, or from a solution of the chemical dissolved in acetone or methylene chloride.

**KEY REFERENCES:** 3; 4; 5; 6; 15.

**CHLOROBROMOMETHANE (CH<sub>2</sub>BrCl, 129.39)**

**CAS/DOT IDENTIFICATION #:** 74-97-5/UN1887

**SYNONYMS:** bromochloromethane, fluorocarbon 1011, halon<sup>®</sup>1011, methylene chlorobromide.

**PHYSICAL PROPERTIES :** colorless to pale-yellow liquid; chloroform-like odor; soluble in most organic solvents; poor solubility in water; MP (-88°C, -126°F); BP (68°C, 154°F); DN (1.930 g/mL at 25°C); LSG (1.93); CP (52.7 J/K-mol gas at 25°C); HV (32.85 kJ/mol at 25°C); VD (4.46); VP (115 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; attacks many metals including steel, aluminum, magnesium, and zinc unless inhibited; FP (none); LFL/UFL (none); AT (none).

**EXPLOSION and FIRE CONCERNS:** noncombustible liquid; dangerous substance; decomposes on heating producing toxic and corrosive fumes including hydrogen chloride, phosphene and hydrogen bromide; incompatible with chemically-active metals such as calcium, powdered aluminum, zinc, and magnesium; all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, drowsiness, headache, nausea, lung edema, effects on central nervous system, blood effects, lowering of consciousness); skin contact (dry skin, redness, dermatitis); eye contact (redness); ingestion (effects on the liver and kidney).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if swallowed, do not induce vomiting; refer for immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans; should be considered at least as toxic as carbon tetrachloride.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and throat; dizziness; headache; drowsiness; confusion; central nervous system depression; pulmonary edema; may cause effects on blood, resulting in the formation of carboxyhemoglobin; lowering of consciousness.

**CHRONIC HEALTH RISKS:** impairment of kidney and liver functions; lungs may be affected by prolonged exposure; may cause dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm (1060 mg/m<sup>3</sup>); OSHA PEL TWA 200 ppm (1050 mg/m<sup>3</sup>); NIOSH REL TWA 200 ppm (1050 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use safety spectacles or eye protection in combi-

nation with breathing protection; a system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; use positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; a filter for organic vapors may be employed for extra protection.

**SPILL CLEAN-UP:** collect leaking liquid in sealable containers; absorb remaining liquid in noncombustible materials (e.g. dry earth, sand, vermiculite), and place in a chemical waste container; flush remaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent and remove to a sanitary landfill; dispose of container and unused contents in accordance with federal, state, and local requirements; store in a cool, dry location; maintain adequate ventilation; separate from food and feedstuffs.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (6.1); label (keep away from food).

**OTHER COMMENTS:** used in fire extinguishers; useful in organic synthesis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### **CHLORODIPHENYL (42% Chlorine) (C<sub>6</sub>H<sub>4</sub>ClC<sub>6</sub>H<sub>3</sub>Cl<sub>2</sub> (approx), 258 (approx))**

**CAS/DOT IDENTIFICATION #:** 53469-21-9/UN2315

**SYNONYMS:** aroclor<sup>®</sup> 1242, pcb, polychlorinated biphenyl.

**PHYSICAL PROPERTIES :** colorless to light-colored, viscous liquid; mild hydrocarbon odor; solubility in water is extremely low; soluble in oils and organic solvents; does not crystallize upon heating or cooling, but at a specific temperature, defined as a "pour point", changes into a resinous state; MP (-19°C, -2.2°F)(pour point); BP (325-366°C, 617-691°F); DN (1.38 g/mL at 20°C); LSG (1.39 at 25°C); VS (data not available); VD (8.9); VP (0.001 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; stable to acids and alkali; resistant to oxidation but are subject to photodechlorination when exposed to sunlight; will attack some forms of plastics, rubber, and coatings; can react with strong oxidizing agents; FP (176°C, 349°F); LFL/UFL (data not available); AT (data not available).

**EXPLOSION and FIRE CONCERNS:** nonflammable liquid; may burn but does not ignite readily; containers may explode when heated; exposure in a fire results in the formation of a black soot containing polychlorinated biphenyls, polychlorinated dibenzofurans and chlorinated dibenzo-p-dioxins; contact with strong oxidizers may cause fires and explosions; toxic gases and vapors, such as hydrogen chloride and carbon monoxide, may be released in a fire; use dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (pulmonary effects, injury to liver, irritates eyes, nose and throat); contact (acne-like skin rash, dermatitis, hyper-pigmentation); ingestion (gastrointestinal disturbances, yellow jaundice, dark urine, fatigue).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxy-

gen; administer artificial respiration if breathing has stopped; in case of ingestion, induce vomiting by administering syrup of ipecac; seek immediate medical attention

**HUMAN TOXICITY DATA:** inhalation-human  $\text{TCLo}$   $10 \text{ mg/m}^3$ ; toxic effect: pulmonary, liver effects.

**ACUTE HEALTH RISKS:** irritation to eyes, nose, and throat; may cause an acne-like skin rash; may also injure the liver, resulting in such effects as fatigue, dark urine, and yellow jaundice; gastrointestinal disturbances, and numbness of the extremities have been reported.

**CHRONIC HEALTH RISKS:** produces tumors of the liver and pituitary gland in animals; may cause adverse reproductive effects; is a defatting agent and can cause dermatitis on prolonged exposure; may cause hyper-pigmentation; elevated serum enzyme and triglyceride levels have been reported; considered to be a potential human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $1 \text{ mg/m}^3(\text{skin})$ ; ACGIH TLV STEL  $2 \text{ mg/m}^3(\text{skin})$ ; OSHA PEL TWA  $1 \text{ mg/m}^3(\text{skin})$ ; NIOSH REL TWA  $0.001 \text{ mg/m}^3$ .

**PERSONAL PROTECTION:** wear chemical protective clothing consisting of zippered coverall with attached hood and drawstring, elastic cuffs, gloves, and closure boots; it is recommended that outer coveralls should be made of chemically resistant materials such as Saranax<sup>®</sup>-coated Tyvek or Viton<sup>®</sup>-coated neoprene; gloves and boots should be made of neoprene, nitrile, butyl rubber or Viton; wear splash-proof safety goggles; a closed system of local exhaust ventilation is required to control emissions at the source and to prevent dispersion into general work area; a self contained breathing apparatus operated in positive pressure mode should be worn where a risk of exposure to airborne contaminants exists; for extra personal protection, air-purifying full face-piece respirators equipped with a high efficiency particulate air filter and organic vapor cartridge may be employed.

**SPILL CLEAN-UP:** dry sand or earth should be spread on the leak, or spill area; bulk liquid may also be absorbed with fly ash or cement powder; cleanup of areas contaminated with soot should involve dry vacuuming of surfaces with a vacuum cleaning system equipped with a high efficiency particulate (HEPA) filter; after preliminary cleanup, wash surfaces with alkaline or nonionic synthetic detergents in water; clean nonporous electrical and mechanical equipment with organic solvents; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of by absorbing it in dry earth, sand or vermiculite, and disposing in a secured sanitary landfill; may also be dissolved in a more flammable solvent (such as #2 fuel oils) and disposed of in a cement kiln incinerator with a temperature range of  $1400\text{-}1450^\circ\text{C}$ ; destruction may also be accomplished by using a modified rotary kiln incinerator with liquid injection burner operating at a temperature range of  $1252\text{-}1339^\circ\text{C}$ , and the afterburner operating at  $1331\text{-}1332^\circ\text{C}$  with a residence time of 3.0-3.2 sec; should be stored in closed containers, in well-ventilated areas; storage site should be as close as practicable to a lab in which carcinogens are to be used; separate from strong oxidizers.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used in the manufacture and application for use as pesticides and fungicides; used as a dielectric in manufacture of transformers, resistors, and capacitors; used as a sealer for rubber and synthetic gaskets; utilized in processing of plastics for flame retardancy, as an intermediate in organic synthesis, and in the manufacture of adhesives and weatherizers used in spray surface coatings.

**KEY REFERENCES:** 4; 5; 6; 14; 15; 16.

**CHLORODIPHENYL (54% Chlorine) (C<sub>6</sub>H<sub>3</sub>Cl<sub>2</sub>C<sub>6</sub>H<sub>2</sub>Cl<sub>3</sub> (approx), 327(average))****CAS/DOT IDENTIFICATION #:** 11097-69-1/UN2315

**SYNONYMS:** aroclor<sup>®</sup>1254, chlorobiphenyl (54% chlorine), pcb, polychlorinated biphenyl.

**PHYSICAL PROPERTIES :** colorless to pale yellow, viscous liquid; changes into a resinous state (pour point) at 10°C; exits as a solid below 10°C (50°F); mild, hydrocarbon odor; insoluble in water; MP (10°C, 50°F); BP (365-390°C, 689-734°F); DN (1.5 g/mL); LSG (1.38 at 25°C); VP (6 x 10<sup>-5</sup> mmHg at 20°C); DR (365-390°C, 689-734°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; resistant to acids and alkalies; no open cup flash point to boiling; reacts vigorously with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** nonflammable liquid; exposure in a fire results in the formation of a black soot containing PCB's, polychlorinated dibenzofurans, and chlorinated dibenzo-p-dioxins; not combustible; decompress in a fire producing toxic fumes of Cl<sup>-</sup>; use powder and carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes); skin absorption (dry skin, redness, chloracne); ingestion (headache, numbness, fever, reproductive effects, liver damage).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, provide rest and get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes; headache; numbness; fever; dry skin; chloracne.

**CHRONIC HEALTH RISKS:** may cause dermatitis chloracne; may have effects on the liver; possibly causes toxic effects upon human reproduction

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.5 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.001 mg/m<sup>3</sup>; IDLH 5mg/m<sup>3</sup> (NIOSH considers this substance to be a potential occupational carcinogen).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear chemical safety goggles in combination with breathing protection; a system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; use self-contained breathing apparatus in oxygen deficient atmospheres.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking liquid in sealable containers; absorb remaining liquid in noncombustible materials (dry earth, sand, vermiculite), and place in chemical waste containers or remove to a safe place; this substance should not be allowed to enter the environment.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent and place in a secured, sanitary landfill; store in a cool, dry location; keep in a well-ventilated room; separate from food and feedstuffs.

**REGULATORY INFORMATION:** S1; Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; CW4; CW5; A1; CAL.

**OTHER COMMENTS:** used in heat transfer, lubricants, hydraulic fluids, and insecticides; also used as a plasticizer for cellulose, vinyl resins, and chlorinated rubbers.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

### CHLOROFORM (CHCl<sub>3</sub>, 119.38)

**CAS/DOT IDENTIFICATION #:** 67-66-3/UN1888

**SYNONYMS:** methane trichloride, methenyl chloride, trichloroform, trichloromethane.

**PHYSICAL PROPERTIES :** clear, colorless, liquid; pleasant, sweet odor; miscible with alcohol, ether, benzene, carbon disulfide, petroleum ether, carbon tetrachloride, fixed and volatile oils; very refractive liquid; MP (-63°C, -82°F); BP (62°C, 143°F); DN (1.4832 g/cm<sup>3</sup> at 20°C); LSG (1.48); ST (27.1 dynes/cm at 20°C); VS (5.63 mP at 20°C, 5.10 mP at 30°C); CP (114.2 J/mol-K liquid at 298.15K); HV (59.3 cal/g, 2.483 x 10<sup>5</sup> J/kg); VD (4.13); VP (100mmHg at 10.4°C, 159mmHg at 20°C, 245mmHg at 30°C); OT(3.30 mg/L).

**CHEMICAL PROPERTIES:** generally stable; will not polymerize; reacts vigorously with disilane when exposed to sunlight; addition to acetone in the presence of a base will result in a highly exothermic reaction; addition to methanol in the presence of sodium hydroxide will result in an exothermic reaction; develops acidity from prolonged exposure to air and light; HF (134.5 kJ/mol liquid at 25°C); H<sub>f</sub> (8.8 kJ/mol at 209.5K).

**EXPLOSION and FIRE CONCERNS:** practically nonflammable; NFPA rating Health 2, Flammability 0, Reactivity 0; forms explosive mixtures with chemically active metals such as aluminum or magnesium powder, sodium and potassium; reacts violently with acetone and a base, aluminum disilane, lithium, magnesium, nitrogen tetroxide, potassium-tert-butoxide, and sodium methylate; incompatible with strong caustics, fluorine, sodium hydroxide, methanol, and sodium methoxide; ignites on contact with water; when heated to decomposition, emits toxic fumes of hydrogen chloride gas, phosgene gas, carbon monoxide, and carbon dioxide; use water to keep fire exposed containers cool; use suitable extinguishing agent for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of the upper respiratory tract, headache, dizziness, and drowsiness); skin contact (irritation, dermatitis); eye contact (irritation, corneal damage); ingestion (nausea, vomiting, gastrointestinal irritation, burns to mouth and throat).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 25,000ppm/5months; inhalation-human TCLo 5000mg/m<sup>3</sup>/7months; oral-human LDLo 140mg/kg..

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and mucous membranes; headaches; dizziness; mental dullness; nausea; vomiting; hallucinations; unconsciousness; fatigue; death in high exposures.

**CHRONIC HEALTH RISKS:** kidney and liver damage; cardiac damage; respiratory failure; hypotension; toxemia; paralysis; may alter genetic material.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm (49mg/m<sup>3</sup>); OSHA PEL TWA 2ppm (9.78mg/m<sup>3</sup>); ceiling level 50ppm (240 mg/m<sup>3</sup>); NIOSH REL ceiling level 2ppm/60min; IDLH 500ppm.

**PERSONAL PROTECTION:** wear full protective clothing (boots, gloves, sleeves, aprons, etc.); wear chemical safety goggles; in high concentrations of vapor, wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible with materials such as dry earth or sand.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; recover through distillation or steam stripping; store in cool, dry, well-ventilated location; keep containers tightly closed; isolate from strong alkalis and strong mineral acids.

**REGULATORY INFORMATION :** CA2; S3; S40-e; R2-26; R3; R4; R5; R7; R8; R9; D waste # (D022); U waste # (U044); Reportable Quantity (RQ): 10lbs (4.54 kg); Sf1; Sf2; Sf3; CW1; CW2; CW3; CW4; CW5; A1; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a component of cough syrups; used as a component of liniments; used as a general solvent for adhesives, pesticides, fats, rubbers, waxes, resins, and penicillins.

**KEY REFERENCES:** 1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14.

## **BIS(CHLOROMETHYL)ETHER ((CH<sub>2</sub>Cl)O(CH<sub>2</sub>Cl), 115.00)**

**CAS/DOT IDENTIFICATION #:** 542-88-1/UN2249

**SYNONYMS:** BCME, chloromethyl ether, dichlorodimethylether; dichloromethyl ether, oxybis (chloromethane).

**PHYSICAL PROPERTIES:** colorless liquid; suffocating odor; miscible with alcohol, ether, and many organic solvents; not soluble in water; MP (-42°C, -43°F); BP (106°C, 223°F); DN (1.323 g/mL at 15°C); LSG (1.32); VD (4.0); VP (30mmHg at 22°C).

**CHEMICAL PROPERTIES:** unstable in moist air; highly volatile; reacts vigorously with acids and water; reacts with water to form hydrochloric acid and formaldehyde; attacks rubber and most forms of plastic; forms shock-sensitive compounds when exposed to oxidizing materials, peroxides, or sunlight; FP(<19°C, <66°F).

**EXPLOSION and FIRE CONCERNS:** dangerous fire hazard; NFPA rating Health 4, Flammability 3, Reactivity 1; can form peroxides which can detonate when heated; explosion from air mixtures of ether vapors; can ignite by electric sparks; may generate electrostatic charges; decomposes on heating; when heated to decomposition, emits corrosive vapors and toxic fumes of Cl<sup>-</sup>; vapors are heavier than air and may travel to a source of ignition and flash back; use dry chemical, alcohol foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); contact (redness, burning, prickling); ingestion (abdominal pain, vomiting, sore throat, labored breath).

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**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** dns-human fibroblast 160µg/L; inhalation-man TCLo 3ppm; toxic effect: eye; inhalation-man LCLo 100ppm/3M; toxic effect: pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and mucous membranes; respiratory system effects; lung irritation; pulmonary edema; congestion; abdominal cramps; nausea; vomiting; sore throat; dizziness; headache; hemorrhage.

**CHRONIC HEALTH RISKS:** impaired respiratory function; lung edema; lung cancer; chronic bronchitis; chronic cough..

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.001ppm; OSHA cancer suspect agent; NIOSH occupational carcinogen.

**PERSONAL PROTECTION:** wear gas-tight, fireproof suit; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb in noncombustible material for proper disposal; treat residues and wastes with concentrated aqueous ammonia; keep water away from release; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in a sanitary landfill; store in a cool, dry, well-ventilated location; outside storage is preferred.

**REGULATORY INFORMATION :** CA2; R7; R8; Reportable Quantity (RQ): 10lbs (4.54 kg); Sf1; Sf2; A5; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a lab reagent and research chemical; used as an alkylating agent in the manufacture of polymers; used as a monitoring indicator for chloromethyl ether.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 13; 14.

### **CHLOROMETHYL METHYL ETHER (C<sub>2</sub>H<sub>5</sub>ClO, 80.5)**

**CAS/DOT IDENTIFICATION #:** 107-30-2/UN1239

**SYNONYMS:** chlorodimethyl ether, chloromethoxymethane, dimethylchloroether, methylchloromethylether.

**PHYSICAL PROPERTIES:** colorless liquid; irritating odor; decomposes easily in water; MP (-103°C, -154°F); BP (59°C, 138°F); DN (1.0605 g/mL at 20°C); LSG (1.06); VP (192 mmHg at 70°F).

**CHEMICAL PROPERTIES:** volatile liquid; polymerization may be caused by oxidizers, peroxides, elevated temperature, or sunlight; reacts with water to form hydrochloric acid and formaldehyde; prepared by passing hydrochloric acid through a mixture of formalin and methanol; FP(15°C, 60°F).

**EXPLOSION and FIRE CONCERNS:** extremely flammable; NFPA rating Health 3, Flammability 3, Reactivity 2; combustion may produce toxic gases and vapors, such as phosgene, carbon monoxide, and hydrogen chloride; vapors are heavier than air and may travel to a source of ignition and flash back; decomposes in water producing hydrogen chloride and formaldehyde; vapor/air mixtures are explosive; reacts with rubber; readily hydrolyzed; caustic to

metals present in water; when heated to decomposition, emits toxic fumes of Cl<sup>-</sup> and forms peroxides; closed containers may rupture violently when heated; use dry chemical, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); skin absorption (coughing, respiratory system, headache, nausea).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** dni-human lymphocyte 5mL/L; target organs: lungs, eyes, kidneys.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory tracts; destructive to tissues of mucous membranes; coughing; wheezing; laryngitis; shortness of breath; pulmonary edema; inflammation of larynx and bronchi; pneumonitis; headache; nausea; vomiting; death in high exposures.

**CHRONIC HEALTH RISKS:** chronic bronchitis; tumors; OSHA-regulated carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV, Suspected Human Carcinogen; OSHA, Cancer Suspect Agent; NIOSH REL TWA use 29 CFR 1910.1006.

**PERSONAL PROTECTION:** wear special protective clothing and chemical-resistant gloves, wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with noncombustible material such as dry earth or sand for proper disposal; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** mix with a combustible solvent and burn in chemical incinerator equipped with afterburner and scrubber; store in a cool, dry location; outside storage preferred; isolate from oxidizing materials and peroxides.

**REGULATORY INFORMATION :** CA2; R4; U waste # (U046); Reportable Quantity (RQ): 10lbs (4.54kg); Sf1; Sf2; Sf3; A1; A5; OSHA Threshold Quantity (TQ): 500lbs (226.8kg); CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid).

**OTHER COMMENTS:** used as a chloroalkylating agent in the preparation of anionic exchange resins; used in the production of chloromethylated compounds; used as a military poison.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14.

## **1-CHLORO-1-NITROPROPANE (C<sub>3</sub>H<sub>6</sub>ClNO<sub>2</sub>, 123.55)**

**CAS/DOT IDENTIFICATION #:** 600-25-9/none

**SYNONYMS:** chloronitropropane, korax<sup>®</sup>, lanstan<sup>®</sup>.

**PHYSICAL PROPERTIES:** colorless liquid; pungent, acrid odor; slightly soluble in water; miscible with most organic solvents; MP (no data found); VP (145°C, 293°F); DN (1.209 g/mL at 20°C); LSG (1.21); VD (4.26); VP (5.8 mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; incompatible with strong bases and strong oxidizing

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agents; FP (62.2°C, 144°F); LFL/UFL (no explosion limits are available for this compound); AT (no data found); HC (no data found).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; flammable liquid when exposed to heat and flame; moderately explosive when subjected to elevated temperatures; NFPA rating Health (not rated), Flammability 2, Reactivity 3; contact with strong oxidizers will cause fire and explosion; decomposition products are corrosive; heating to decomposition emits toxic fumes of Cl<sup>-</sup> and oxides of nitrogen; use carbon dioxide, dry chemical powder or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates mucous membranes, allergic respiratory reaction, lacrimation); contact (irritates skin, allergic skin reaction) ingestion (injury to liver, kidneys, and cardiovascular system).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; administer oxygen if breathing is difficult; if breathing has stopped, administer artificial respiration; if this chemical has been swallowed, seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to mucous membranes; can cause skin irritation; can cause allergic skin reaction; can cause allergic respiratory reaction; lachrymator - causes severe eye irritation; can cause pulmonary edema, based on testing in animals; may be fatal if ingested.

**CHRONIC HEALTH RISKS:** can cause injury to liver and kidneys; can cause injury to the cardiovascular system; mutation data has been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm; OSHA PEL TWA 20 ppm (100 mg/m<sup>3</sup>); NIOSH REL TWA 2 ppm (10 mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use splash-proof safety goggles; enclose operations and/or provide local exhaust ventilation at the site of chemical release; handle chemical only in a fume hood; appropriate respirators are needed in areas where exposures are above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; absorb liquid with inert materials (e.g., dry earth, sand or vermiculite), and place in a chemical waste container; wash contaminated surfaces to remove any residues; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of by burning in a chemical incinerator equipped with afterburner and scrubber; disposal must be in accordance with federal, state, and local regulations; store in tightly closed containers in a cool, dry place; store only with compatible chemicals; maintain adequate ventilation.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none); label (none).

**OTHER COMMENTS:** it should be noted that this chemical, 1-chloro-1-nitropropane, should be furnished for lab use only. This material may not be used as drugs, cosmetics, food additives, agricultural products, pesticidal products, and as household chemicals.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

**CHLOROPICRIN (CCl<sub>3</sub>NO<sub>2</sub>, 164.37)**

**CAS/DOT IDENTIFICATION #:** 76-06-2/UN1580, UN1583(mixture), UN2929 (flammable mixture).

**SYNONYMS:** acquinite, nitrochloroform, nitrotrichloromethane, trichloronitromethane.

**PHYSICAL PROPERTIES :** colorless to faint-yellow, slight oily liquid; intense odor; practically insoluble in water; miscible with alcohol, benzene, and carbon disulfide; soluble in ether; MP (-64°C, -83°F); BP (112°C, 234°F at 757 mmHg); DN (1.6483 g/mL at 25°C, 1.6558 g/mL at 20°C); LSG (1.66); VD (6.69); VP (20 mmHg at 20°C, 40 mmHg at 33.80°C).

**CHEMICAL PROPERTIES:** relatively stable under ordinary conditions of use and storage; hazardous polymerization will not occur; very refractive liquid; reacts vigorously with strong oxidizers, bases, and reducing agents; it has been reported that chloropicrin may photochemically transform into phosgene (COCl<sub>2</sub>); no decomposition by water or mineral acids; FP (-17°C, 1.4°F); LFL/UFL (2%, 13%); AT (464°C, 867.2°F).

**EXPLOSION and FIRE CONCERNS:** pure product is nonflammable and noncombustible liquid; if contaminated, material may explode when heated under confinement; NFPA rating Health 4, Flammability 0, Reactivity 3; closed container may rupture violently when heated; can be shocked into detonation above a critical volume; forms shock- and heat-sensitive explosive mixture with 3-bromopropyne; reacts violently with aniline and heat, alcoholic sodium hydroxide, sodium methoxide, and propargyl bromide; decomposes explosively at elevated temperatures; hazardous decomposition products include carbon dioxide, carbon monoxide, and very toxic fumes of Cl<sup>-</sup> and oxides of nitrogen; use carbon dioxide, dry chemical powder or appropriate foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (lacrimation, conjunctiva irritation, pulmonary changes, vomiting, bronchial or pulmonary lesions); skin absorption (vomiting, bronchitis, pulmonary edema); contact (smarting pain in the eyes, increased skin sensitivity, dermatitis, irritates mucous membranes); ingestion (severe nausea, vomiting, colic, diarrhea).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; cleanse affected areas of skin with plenty of soap and water; if inhaled, remove to fresh air; give oxygen and/or respiratory support if needed; rinse mouth out with water if ingested; do not give liquids and/or induce vomiting to unconscious person; obtain immediate medical attention.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 2mg/m<sup>3</sup>; toxic effects: eye, pulmonary system; inhalation-human TCLo 2000mg/m<sup>3</sup>/10M.

**ACUTE HEALTH RISKS:** can cause severe irritation of skin and eyes; irritation of mucous membranes and upper respiratory tract; lacrimation; cough; pulmonary edema; bronchitis; bronchial or pulmonary lesions; irritation to gastrointestinal tract; nausea; vomiting; may interfere with the transport of oxygen from the lungs to other living tissues in the body.

**CHRONIC HEALTH RISKS:** can cause dermatitis; damage to the liver and kidney; primary lethal effect is to produce lung injury.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; OSHA PEL TWA 0.1 ppm (0.1 mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.7mg/m<sup>3</sup>); IDLH 2 ppm.

## 502 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; chemical should be handled only in a hood; use positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** releases may require evacuation; ventilate area of leak or spill; use water spray to cool and disperse vapors; absorb as much as possible with vermiculite or other inert material; sweep up and place in an appropriate container for proper disposal; wash contaminated surfaces to remove any residues.

**DISPOSAL AND STORAGE METHODS:** dissolve in a flammable solvent and burn in a chemical incinerator equipped with an afterburner and scrubber; disposal must be in accordance with federal, state, and local regulations; store in a cool, dry place; maintain adequate ventilation; store only with compatible chemicals; separate from oxidizing materials; keep in tightly closed containers; outside storage is preferred.

**REGULATORY INFORMATION:** S3; F1; F2; Sf3; A1; CAL; DOT hazard class/division (6.1); labels (poison) (UN1580); DOT hazard class/division (6.1); labels (poison, keep away from food)(UN1583).

**OTHER COMMENTS:** used in organic synthesis, especially in the preparation of methyl violet; useful as a fumigant, a soil insecticide, tear gas, and a rat exterminator; has also been used in disinfecting cereals and grains.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 12; 14.

### BETA-CHLOROPRENE (C<sub>4</sub>H<sub>5</sub>Cl, 88.54)

**CAS/DOT IDENTIFICATION #:** 126-99-8/1991

**SYNONYMS:** 2-chloro-1,3-butadiene, chlorobutadiene, chloroprene, neoprene.

**PHYSICAL PROPERTIES:** colorless liquid; vapor has pungent, ether-like odor; soluble with ether, acetone, and benzene; soluble in alcohol and diethyl ether; very slightly soluble in water; MP (-130°C, -202°F); BP (59.4°C, 139°F); DN (0.9583 g/cm<sup>3</sup> at 20°C); LSG (0.96); VD (3.0); VP (174 mmHg at 20°C); OT (15 ppm, 55mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** polymerizes at room temperature unless inhibited with antioxidants; reacts with peroxides and other oxidizers; reacts vigorously with liquid or gaseous fluorine; FP(-20°C, -4°F); LFL/UFL (4.0%, 20.0%); AT (4.0°C, 39°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; very dangerous fire hazard when exposed to heat or flame; explosive in vapor form when exposed to heat or flame; autooxidizes in air to form an unstable peroxide that catalyzes exothermic polymerization of the monomer; incompatible with liquid or gaseous fluorine; incompatible or reacts violently with chromic anhydride; when heated to decomposition, emits toxic fumes of Cl<sup>-</sup>; use carbon dioxide, dry chemicals, water spray, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (fatigue, psychic changes, oppression in chest, substernal pain, tachycardia); skin absorption (dermatitis, temporary loss of hair).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** cytogenetic analysis-human unreported 1 mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; nervousness; irritability; dermatitis; alopecia; asphyxia; corneal necrosis; conjunctivitis; anemia.

**CHRONIC HEALTH RISKS:** severe degenerative changes in vital organs; reproductive effects; questionable carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (skin); OSHA PEL TWA 25 ppm (skin); NIOSH REL CL 1 ppm (3.6 mg/m<sup>3</sup>); IDLH 300 ppm.

**PERSONAL PROTECTION:** wear protective clothing and chemical safety goggles; wear an air-supplied respirator or self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb on paper towels and evaporate in a fume hood; cautiously ignite paper in open areas away from combustible materials; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** must be destroyed in special waste incinerators equipped with afterburner and scrubber; due to high reactivity and volatility, landfilling is not recommended.

**REGULATORY INFORMATION:** CA2; R3; R4; R5; Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf4; T120-a; CAL; DOT hazard class/division (3); labels (flammable liquid, poison).

**OTHER COMMENTS:** an oil-resistant synthetic rubber (neoprene) may be made by the polymerization of chloroprene; used as a component of adhesives intended for use in food packaging; used for roof coatings; used for wire and cable jackets.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 13; 14.

## 2-CHLORO-6-(TRICHLOROMETHYL)PYRIDINE (C<sub>5</sub>H<sub>3</sub>NCCl<sub>3</sub>, 230.90)

**CAS/DOT IDENTIFICATION #:** 1929-82-4/none

**SYNONYMS:** 2-chloro-6-trichloromethyl pyridine, nitrapyrin, n-serve<sup>®</sup> nitrogen stabilizer, 2,2,2,6-tetrachloro-2-picoline.

**PHYSICAL PROPERTIES:** colorless or white, crystalline solid; mild, sweet odor; very slightly soluble in water; MP (62-63°C, 143.6-145.4°F); BP (136-137.5°C, 276.8-279.5°F at 11 mmHg); DN/SG (no information found); VD (NA); VP (0.003 mmHg at 73°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with aluminum and magnesium; FP (no information found); LFL/UFL (no information found); AT (no information found); HC (no information found).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating (not rated); highly explosive; contact with aluminum and/or magnesium will cause fire and explosions; heating to decomposition emits oxides of nitrogen and chloride ion; water may be used for fire-fighting purposes.

## 504 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**HEALTH SYMPTOMS:** inhalation (mild irritant effects to skin, eyes, and mucous membranes); contact (moderately toxic by skin contact); ingestion (no adverse effects have been noted).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; flush affected areas of skin with large amounts of soap and water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, give plenty of water or milk to drink; seek medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** it has been reported that this chemical is a mild irritant at the point of exposure and is slightly toxic. No adverse effects have been noted with regard to ingestion studies in animals.

**CHRONIC HEALTH RISKS:** experimental reproductive effects have been reported; mutation data has also been noted.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; ACGIH TLV STEL 20 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg (total dust)/m<sup>3</sup>; NIOSH REL STEL 20 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron, or coveralls; wear chemical safety goggles; use hood or other local exhaust ventilation to maintain exposure below threshold limit value (TLV) for nuisance dust; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in unknown concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** sweep into beaker or other container; if appropriate, moisten first in order to prevent dispersion of dust; hold for disposal.

**DISPOSAL AND STORAGE METHODS:** as hazardous solid waste, this chemical must be disposed of in a licensed hazardous waste treatment facility, in accordance with federal, state, and local regulations; store in a cool, dry location; use with adequate ventilation; isolate container in open air; separate from incompatibles, such as aluminum and magnesium

**REGULATORY INFORMATION:** Sf3; A1; CAL; DOT hazard class/division (none); label (none required).

**OTHER COMMENTS:** used as a fertilizer additive to inhibit nitrification and to prevent loss of nitrogen in soil.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

**CHROMIC ACID AND CHROMATES (as CrO<sub>3</sub>):** Chromates (i.e., chromium (VI) compounds) have variable molecular formulas and variable formula weights. The molecular formula for chromic acid is CrO<sub>3</sub>. The formula weight of chromic acid is 100.0

**CAS/DOT IDENTIFICATION #:** Chromates have variable CAS #s and variable DOT identification numbers. The CAS # for chromic acid is 133-82-0. The DOT identification numbers for chromic acid are as follows: UN1463/NA 1463 (acid, solid), UN1755 (acid, solution).

**SYNONYMS:** Synonyms of chromates vary depending upon the specific compound. Synonyms of chromic acid ( $\text{CrO}_3$ ) are as follows: chromic anhydride, chromic oxide, chromium (VI) oxide (1:3); chromium trioxide, monochromium trioxide.

**PHYSICAL PROPERTIES:** Physical properties of chromic acid and specific chromates are provided for illustrative purposes. (chromic acid): dark-red, rhombic crystals or powder; deliquescent (i.e., able to absorb atmospheric water vapor and become liquid); odorless; true chromic acid, sulfuric acid, exists only in solution; very soluble in water, soluble in sulfuric acid and most organic solvents; MP ( $197.2^\circ\text{C}$ ,  $387^\circ\text{F}$ ); BP ( $250^\circ\text{C}$ ,  $482^\circ\text{F}$ )(decomposes); DN ( $2.70 \text{ g/cm}^3$  at  $20^\circ\text{C}$ ); SG (2.70); VD (NA); VP (very low); (potassium chromate) lemon-yellow, rhombic crystals; odorless solid; soluble in water; insoluble in alcohol, acetone, and cyanogen; MP ( $975^\circ\text{C}$ ,  $1787^\circ\text{F}$ ); BP (data not available); DN ( $2.73 \text{ g/cm}^3$  at  $18^\circ\text{C}$ ); SG (2.7 at  $20^\circ\text{C}$ ); VD (NA); VP (approximately 0 mmHg at  $20^\circ\text{C}$ ); (sodium dichromate) reddish to bright orange crystals; odorless solid; somewhat deliquescent; anhydrous; very soluble in water; insoluble in alcohol; MP ( $357^\circ\text{C}$ ,  $674.6^\circ\text{F}$ ); BP ( $400^\circ\text{C}$ ,  $752^\circ\text{F}$ ) (decomposes); DN ( $2.348 \text{ g/cm}^3$  at  $25^\circ\text{C}$ ); SG (2.34); VD (NA); VP (approximately 0 mmHg at  $20^\circ\text{C}$ ).

**CHEMICAL PROPERTIES:** Chemical properties of chromic oxide and specific chromates are provided for illustrative purposes. (chromic acid) powerful oxidizer; oxidizes alcohol and most other organic substances; material is corrosive to many metals; reacts with a broad range of materials; decomposes at  $250^\circ\text{C}$  to chromium (III) oxide ( $\text{Cr}_2\text{O}_3$ ) and oxygen; (potassium chromate) powerful oxidizer; aqueous solution is alkaline to litmus or phenolphthalein; corrosive to metals. (sodium dichromate) powerful oxidizer; deliquescent in moist air; becomes anhydrous on prolonged heating at  $100^\circ\text{C}$  (i.e., loses  $2\text{H}_2\text{O}$  on prolonged heating at  $100^\circ\text{C}$ ); anhydrous salt starts to decompose at  $400^\circ\text{C}$  ( $752^\circ\text{F}$ ).

**EXPLOSION and FIRE CONCERNS:** Chromic acid is not combustible in itself, but will accelerate the burning of combustible materials; chromic acid will ignite on contact with acetic acid and alcohol; chromic acid or chromates will attack most forms of metals, cloth, leather, plastics, and coatings, and may cause spontaneous ignition; contact with any combustible, organic, or other readily oxidizable materials such as wood, paper, aluminum, sulfur, plastics, etc., may result in fires and explosions; chromic acid will undergo decomposition at  $250^\circ\text{C}$  ( $482^\circ\text{F}$ ) with release of oxygen; chromium fumes are produced in a fire involving chromic acid; use flooding quantities of water as spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, wheezing, dyspnea, cough, chest pain, irritates larynx, lungs, and skin); contact (conjunctivitis, erosion and discoloration of teeth, allergic skin rash, skin ulcers); ingestion (vomiting, kidney problems, liver damage, blood changes).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; immediately wash affected areas of skin with plenty of soap or water; if breathing is difficult, provide oxygen; begin artificial respiration if breathing has stopped; in case of ingestion, induce vomiting by giving syrup of ipecac, followed by water; seek medical attention immediately.

**HUMAN TOXICITY DATA:** the following toxicity data refers to chromic acid; inhalation - human  $\text{TCLo } 110 \mu\text{g/m}^3/3\text{Y}$  - continuous; toxic effect: carcinogenic effects; inhalation - human  $\text{TCLo } 110 \mu\text{g/m}^3$ ; cytogenetic - human leukocyte  $2 \text{ mg/L}$ .

**ACUTE HEALTH RISKS:** irritation to nose, throat, bronchial tubes, and lungs; may cause eye injury; chromates and sodium and potassium dichromates may cause stomach and kidney problems; may often cause vomiting; may cause ulceration of the skin.

**CHRONIC HEALTH RISKS:** may cause severe allergic respiratory reaction with symptoms resembling asthma; repeated or prolonged exposure may cause nasal septum perforation; liver damage with yellow jaundice has been reported; other long-term effects include kid-

ney damage, leukocytosis (increased blood leukocytes), leukopenia (reduced blood leukocytes), monocytosis (increased blood monocytes), eosinophilia, conjunctivitis, ulceration of the skin, and sensitization dermatitis; confirmed human carcinogen producing nasal and lung tumors; human mutation data has been reported; experimental teratogenic and reproductive effects have been noted, based on testing in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05 mg (Cr)/m<sup>3</sup>; Confirmed Human Carcinogen; OSHA PEL CL 0.1 mg(CrO<sub>3</sub>)/m<sup>3</sup>; NIOSH REL TWA 0.001 mg (Cr)/m<sup>3</sup>, Potential Occupational Carcinogen, IDLH 15 mg (Cr(VI))/m<sup>3</sup>, Potential Occupational Carcinogen.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; butyl rubber or polyvinyl chloride (PVC) are recommended protective clothing barriers; use chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; wear any self-contained breathing apparatus that has a full face-piece operated in a positive pressure mode where the potential exists for concentrations above the NIOSH REL; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; shovel into suitable dry container and deposit in sealed containers for proper disposal; absorb liquid containing chromic acid or chromates in inert materials, such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** chromic acid and chromates may be disposed of in sealed containers in a secured, sanitary landfill; store in a cool, dry location; maintain adequate ventilation; separate from combustible materials, halogens, sulfides, and metals.

**REGULATORY INFORMATION:** A1; A2; CAL; DOT hazard class/division (5.1); label (oxidizer, corrosive).

**OTHER COMMENTS:** chromic acid and chromates may be used in metal finishing in chrome plating, in leather finishing for glove and garment leathers, and as corrosion inhibitors in radiator coolants; use in photoreproduction processes as sensitizing agents for photography, photoengraving, and blue-printing; utilized in dyeing of fur, leather, fabrics, wool and nylon; used in battery manufacture to increase shelf life and to provide corrosion resistance; has also been used in the manufacture of safety matches and explosives; other uses include a chemical reagent, oxidizing agent, catalyst, in bleaching of fats, oils, and waxes, in manufacture and packaging of cement, and in chemical synthesis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 16.

## CHROMIUM COMPOUNDS (Cr, 52.00)

**CAS/DOT IDENTIFICATION #:** 7440-47-3/variable DOT ID numbers

**SYNONYMS:** chrome, chromium metal (OSHA).

**PHYSICAL PROPERTIES:** steel-gray metallic pieces, powder, and flakes; gray crystals; blue-white hard metal; body-centered cubic structure; ductile; odorless; chromium (III) compounds are sparingly soluble in water; chromium (IV) compounds are readily soluble in water; soluble in acids (except nitric) and strong alkalis; exists in active and passive forms; Cr ion forms many coordination compounds; MP (1890°C, 3434°F); BP (2672°C, 4841.6°F); DN (7.14 g/cm<sup>3</sup> at 20°C); SG (7.14); ST (50 mN/m in air at MP); CP (5.58 cal/g-atom deg at 25°C); HV (81.7 kcal/g-atom); VD (7.1); VP (1mmHg at 1616°C).

**CHEMICAL PROPERTIES:** not oxidized by air, even in presence of much moisture; active form reacts readily with dilute acids to form chromous salts; attacked by caustic alkalis and alkali carbonates; reacts with dilute hydrochloric acid and sulfuric acid;  $LH_f$  (3.5 kcal/g-atom).

**EXPLOSION and FIRE CONCERNS:** powdered form is combustible; NFPA rating Health 0, Flammability 2, Reactivity -; violent or explosive reaction when heated with ammonium nitrate; ignites or reacts violently with bromine pentafluoride; incandescent reaction with nitrogen oxide or sulfur dioxide; reaction with mineral acids may liberate hydrogen gas; reacts readily with dilute acids to form chromous salts; incompatible with oxidants; potentially explosive in atmospheres of carbon dioxide; use dry chemical, carbon dioxide, water spray, fog, or sand for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (eye and skin irritation); contact (corrosive on skin, dermatitis, burning).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin with plenty of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human  $LDLo$  71mg/kg; toxic effect: gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of nose, eyes, and lungs; perforation of the nasal septum; stomach irritation; gastrointestinal effects; neurological effects; coughing; wheezing; skin burns; dyspnea; respiratory tract effects.

**CHRONIC HEALTH RISKS:** increased risk of lung cancer; decreased pulmonary function; pneumonia; bronchitis; asthma; liver and kidney damage; effects on gastrointestinal and immune systems; effects on the blood; contact dermatitis; skin ulcerations; sensitivity; nasal itching and soreness; complications during pregnancy and childbirth; chromate salts are suspected carcinogens.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (Cr metal and Cr (II) and Cr(III) compounds)  $0.5\text{mg}/\text{m}^3$ ; ACGIH TLV TWA (water soluble Cr(VI) compounds)  $0.05\text{ mg}/\text{m}^3$ ; OSHA PEL TWA (Cr metal and insoluble compounds)  $1\text{mg}/\text{m}^3$ ; OSHA PEL TWA (Cr(II) and Cr(III) compounds)  $0.5\text{mg}/\text{m}^3$ ; NIOSH REL CL (chromic acid)  $0.2\text{mg}/\text{m}^3$ ; NIOSH REL TWA (chromic acid)  $0.05\text{mg}/\text{m}^3$ ; NIOSH REL TWA (other Cr(VI) compounds)  $0.025\text{ mg}/\text{m}^3$ ; NIOSH REL TWA (carcinogenic Cr (VI) compounds)  $0.001\text{mg}/\text{m}^3$ ; IDLH (Cr(II) compounds)  $250\text{mg}/\text{m}^3$ ; IDLH (Cr (III) compounds)  $25\text{mg}/\text{m}^3$ .

**PERSONAL PROTECTION:** wear full rubberized safety clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible in dry earth or sand; deposit in sealed containers or place in a secured sanitary landfill; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb spilled material in dry earth or sand, and bury in a sanitary landfill; store in tightly sealed containers; storage should be in a cool, dry, well-ventilated area away from heat and ignition sources.

**REGULATORY INFORMATION:** S<sub>f</sub>4.

**OTHER COMMENTS:** used in the fabrication of alloys; used as a protective coating for automotive and equipment accessories; used in astringents and antiseptics; increases resistance and durability of metals.

**KEY REFERENCES:** 3; 4; 5; 6; 11; 12; 13; 14.

**CLOPIDOL (C<sub>7</sub>H<sub>7</sub>Cl<sub>2</sub>NO, 192.05)**

**CAS/DOT IDENTIFICATION #:** 2971-90-6/none

**SYNONYMS:** coccidiostat<sup>®</sup>, coyden<sup>®</sup>, 3,5-dichloro-2,6-dimethyl-4-pyridinol, methyl-chloropindol.

**PHYSICAL PROPERTIES :** white to light-brown, crystalline solid; insoluble in water; MP (>320°C, >608°F); BP (unknown); DN/SG (unknown); VD (unknown); VP (unknown).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; heat may contribute to instability; no incompatibilities or reactivities reported; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; in cloud form, dust may be explosive if ignited; NFPA rating (not found); poisonous gases, such as hydrogen chloride and oxides of nitrogen, may be released in a fire; use water, carbon dioxide, fog or dry extinguishers for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, throat, and skin); contact (sore throat, coughing, runny nose, redness and itching of eyes).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, rinse mouth cavity several times with water; seek immediate medical attention

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** may cause physical irritation of the eyes; irritation of the skin; sore throat; coughing; runny nose.

**CHRONIC HEALTH RISKS:** no symptoms of chronic exposure to clopidol have been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; ACGIH TLV not classifiable as a human carcinogen; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>; NIOSH REL STEL 20mg(total dust)/m<sup>3</sup>; NIOSH REL TWA 5 mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, and gas-tight suit; wear dust-proof safety goggles when working with powders or dust; a closed system of local exhaust ventilation is required to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where the potential exists for exposures over 10 mg/m<sup>3</sup>; wear positive-pressure self-contained breathing apparatus in high exposures; maintain eyewash baths or safety showers in work area.

**SPILL CLEAN-UP:** cautiously collect spilled material and deposit in sealed containers for proper disposal in an approved facility; absorb liquid containing Clopidol in inert materials (dry earth, sand, vermiculite), and place in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid clopidol-containing formulations in dry sand or inert material, and place in a secured, sanitary landfill; should be disposed of as a hazardous waste, in accordance with federal, state and local regulations; store in a cool, dry, well-ventilated area; storage should be in tightly sealed containers; protect containers of clopidol from physical damage; separate from heat, sparks, and open flame.

**REGULATORY INFORMATION:** A1; CAL; DOT label (none).

**OTHER COMMENTS:** used as an animal antibiotic.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 16.

**COAL DUST (less than 5% SiO<sub>2</sub>)**(Molecular formula and formula weight vary depending upon the specific coal type. Bituminous coal molecules have a mean molecular weight of 2000 or more.)

**CAS/DOT IDENTIFICATION #:** none/none

**SYNONYMS:** anthracite coal dust, anthracite particles, bituminous coal dust, coal facings, coal-milled, lignite coal dust, sea coal.

**PHYSICAL PROPERTIES :** dark-brown to black solid dispersed in air; physical properties vary depending upon the specific coal type; lignite is distinguished as a soft brown coal; bituminous coals can be classified according to their degree of carbonification into flame coal, flame-gas coal, gas coal, fat coal, steam coal, lean coal and anthracite; the carbonaceous content rises from 50 to 91.5%, the oxygen content falls from 44 to less than 2.5%, and the moisture content from 6 to less than 3.8% in the sequence wood, peat, brown coal, bituminous coal, anthracite; soft brown coal contains 30-65% moisture, bituminous coals may contain up to 7% moisture and up to 30% ash; spectroscopy and chemical analyses show that bituminous coal is predominantly of aromatic character; material is insoluble in water.

**CHEMICAL PROPERTIES:** vary depending upon the specific coal type; the carbonization of brown coal yields mainly phenol, as well as paraffins; crude tar, crude benzene, ammonia, methane, ethane and ethylene are obtained in the coking of bituminous coal; distillation of crude tar and crude benzene yields benzene, toluene, xylene, phenol cresols, naphthalene, phthalic acid, N-sulphonic acids, and unsaturated liquid hydrocarbons such as styrene, coumarone, indene and pyridine, crude tar distillation will also yield heavy oils, anthracene oil, and pitch residues; carbon monoxide and hydrogen, obtained from coal gasification, may be used as the starting point for Fischer-Tropsch synthesis, using normal pressures and a cobalt catalyst at 160-205°C, and producing crude kerosene, benzene, gasoline and gas oil; coal or coal products can be hydrogenated to liquid fuels, light oils, lubricant oils, heating oils and kerosene at  $(9.8 \times 10^5 - 980.6 \times 10^5 \text{ Pa})$  and  $(200 - 250^\circ\text{C})$ ; no incompatibilities have been reported in the literature.

**EXPLOSION and FIRE CONCERNS:** combustible solid; slightly explosive when exposed to flame; coal dust/air mixtures containing more than 70 g/m<sup>3</sup> of coal with a 14% content of volatile matter are explosive and can be ignited by high-temperature flames; coal dust explosions consume enormous quantities of oxygen from the atmosphere; NFPA rating (none).

**HEALTH SYMPTOMS:** inhalation (chronic bronchitis, decreased pulmonary function, emphysema, cough, blackish sputum, pneumoconiosis (simple and/or complicated), development of lung lesions, obliterated blood vessels in the lung, may cause failure of the right side of the heart, may obstruct airways).

## 510 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**FIRST AID:** no recommendation is made specifying the need for washing the substance from the skin; if a person breathes large amounts of the chemical, move exposed person to fresh air immediately; other first aid measures are usually not necessary. (note: there is no specific treatment for coalworkers' pneumoconiosis).

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** no information found.

**CHRONIC HEALTH RISKS:** chronic bronchitis; emphysema; simple pneumoconiosis; slight cough; blackish sputum; decreased pulmonary function; complicated pneumoconiosis; reduction in ventilatory capacity; low diffusing capacity; low arterial oxygen tension; pulmonary hypertension; premature death.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 mg(respirable fraction)/m<sup>3</sup>; OSHA PEL TWA 2.4 mg/m<sup>3</sup>/(% SiO<sub>2</sub> + 2) (as respirable fraction <5% SiO<sub>2</sub>); IDLH (not determined).

**PERSONAL PROTECTION:** wear thick working gloves and safety glasses; all persons who work below ground and on designated sites on the mine surface should be provided with suitable protective helmets; an approved dust respirator and a miners' safety lamp are also required.

**SPILL CLEAN-UP:** airborne dust must be diluted by good ventilation; it is almost impossible to capture airborne particles with sprays or aerosols; water must be applied to the point of coal breakage in sufficient quantity in order to reduce dispersion.

**DISPOSAL AND STORAGE METHODS:** no recommendations specifying disposal methods and storage provisions have been found in the literature.

**REGULATORY INFORMATION:** A1; A3.

**OTHER COMMENTS:** brown coal is used primarily for the thermal generation of electricity; large amounts of bituminous coal are turned into coke for metallurgical purposes; organic compounds that occur as by-products are used as feedstock in coal chemistry; even though 31% of the world's primary energy requirements were satisfied by bituminous coal in 1978, the utilization of raw coal for space and process heating is now steadily declining; advanced combustion techniques, such as fluidized-bed combustion, are being increasingly used in industry; gasification and liquefaction processes are now being used to synthesize Substitute Natural Gas (SNG) for chemical processes.

**KEY REFERENCES:** 4; 5; 6; 16.

**COAL DUST (greater than or equal to 5% SiO<sub>2</sub>)**(Molecular formula and formula weight vary depending upon the specific coal type. Bituminous coal molecules have a mean molecular weight of 2000 or more.)

**CAS/DOT IDENTIFICATION #:** none/none

**SYNONYMS:** anthracite coal dust, anthracite particles, bituminous coal dust, coal facings, coal-milled, lignite coal dust, sea coal.

**PHYSICAL PROPERTIES :** dark-brown to black solid dispersed in air; physical properties vary depending upon the specific coal type; lignite is distinguished as a soft brown coal; bituminous coals can be classified according to their degree of carbonification into flame coal, flame-gas coal, gas coal, fat coal, steam coal, lean coal and anthracite; the carbonaceous content

rises from 50 to 91.5%, the oxygen content falls from 44 to less than 2.5%, and the moisture content from 6 to less than 3.8% in the sequence wood, peat, brown coal, bituminous coal, anthracite; soft brown coal contains 30-65% moisture, bituminous coals may contain up to 7% moisture and up to 30% ash; spectroscopy and chemical analyses show that bituminous coal is predominantly of aromatic character; material is insoluble in water.

**CHEMICAL PROPERTIES:** vary depending upon the specific coal type; the carbonization of brown coal yields mainly phenol, as well as paraffins; crude tar, crude benzene, ammonia, methane, ethane and ethylene are obtained in the coking of bituminous coal; distillation of crude tar and crude benzene yields benzene, toluene, xylene, phenol cresols, naphthalene, phthalic acid, N-sulphonic acids, and unsaturated liquid hydrocarbons such as styrene, coumarone, indene and pyridine, crude tar distillation will also yield heavy oils, anthracene oil, and pitch residues; carbon monoxide and hydrogen, obtained from coal gasification, may be used as the starting point for Fischer-Tropsch synthesis, using normal pressures and a cobalt catalyst at 160-205°C, and producing crude kerosene, benzene, gasoline and gas oil; coal or coal products can be hydrogenated to liquid fuels, light oils, lubricant oils, heating oils and kerosene at  $(9.8 \times 10^5 - 980.6 \times 10^5 \text{ Pa})$  and  $(200-250^\circ\text{C})$ ; no incompatibilities have been reported in the literature.

**EXPLOSION and FIRE CONCERNS:** combustible solid; slightly explosive when exposed to flame; coal dust/air mixtures containing more than  $70 \text{ g/m}^3$  of coal with a 14% content of volatile matter are explosive and can be ignited by high-temperature flames; coal dust explosions consume enormous quantities of oxygen from the atmosphere; NFPA rating (none).

**HEALTH SYMPTOMS:** inhalation (chronic bronchitis, decreased pulmonary function, emphysema, cough, blackish sputum, pneumoconiosis (simple and/or complicated), development of lung lesions, obliterated blood vessels in the lung, may cause failure of the right side of the heart, may obstruct airways).

**FIRST AID:** no recommendation is made specifying the need for washing the substance from the skin; if a person breathes large amounts of the chemical, move exposed person to fresh air immediately; other first aid measures are usually not necessary. (note: there is no specific treatment for coalworkers' pneumoconiosis).

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** no information found.

**CHRONIC HEALTH RISKS:** chronic bronchitis; emphysema; simple pneumoconiosis; slight cough; blackish sputum; decreased pulmonary function; complicated pneumoconiosis; reduction in ventilatory capacity; low diffusing capacity; low arterial oxygen tension; pulmonary hypertension; premature death.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $2 \text{ mg}(\text{respirable fraction})/\text{m}^3$ ; OSHA PEL TWA  $10 \text{ mg}/\text{m}^3$  ( $\% \text{ SiO}_2 + 2$ ) (as respirable fraction  $>5\% \text{ SiO}_2$ ); IDLH (not determined).

**PERSONAL PROTECTION:** wear thick working gloves and safety glasses; all persons who work below ground and on designated sites on the mine surface should be provided with suitable protective helmets; an approved dust respirator and a miners' safety lamp are also required.

**SPILL CLEAN-UP:** airborne dust must be diluted by good ventilation; it is almost impossible to capture airborne particles with sprays or aerosols; water must be applied to the point of coal breakage in sufficient quantity in order to reduce dispersion.

**DISPOSAL AND STORAGE METHODS:** no recommendations specifying disposal methods and storage provisions have been found in the literature.

**REGULATORY INFORMATION:** A1; A3.

**OTHER COMMENTS:** brown coal is used primarily for the thermal generation of electricity; large amounts of bituminous coal are turned into coke for metallurgical purposes; organic compounds that occur as by-products are used as feedstock in coal chemistry; even though 31% of the worlds' primary energy requirements were satisfied by bituminous coal in 1978, the utilization of raw coal for space and process heating is now steadily declining; advanced combustion techniques, such as fluidized-bed combustion, are being increasingly used in industry; gasification and liquefaction processes are now being used to synthesize Substitute Natural Gas (SNG) for chemical processes.

**KEY REFERENCES:** 4; 5; 6; 16.

**COAL TAR PITCH VOLATILES** (Properties such as molecular formula and formula weight depend upon the specific compound).

**CAS/DOT IDENTIFICATION #:** 65996-93-2/UN1136

**SYNONYMS:** Synonyms vary depending upon the specific compound (e.g., acridine, chrysene, anthracene, benzo(a)pyrene, phenanthrene, and pyrene). Other commonly used names are: coal tar pitch and pitch.

**PHYSICAL PROPERTIES:** black or dark-brown amorphous residue which remains after coal tar is distilled; chemical mixtures composed almost entirely of polynuclear aromatic compounds; constitutes 48-65% of the usual grades of coal tar; different grades have different softening points (e.g., roofing pitch softens at 65°C (149°F), electrode pitch at 110-115°C (230-239°F); coal tar has a naphthalene-like odor and a sharp, burning taste; soluble in ether, chloroform, carbon disulfide, and benzene; very slightly soluble in water; partial solubility in methanol, acetone, and alcohol; DN (1.18 - 1.23 g/cm<sup>3</sup>); other physical properties vary depending upon the specific compound.

**CHEMICAL PROPERTIES:** properties depend upon the specific component; coal tar may be hydrogenated under pressure to form a petroleum-like fuel suitable for residual use; coal tar pitch is not compatible with strong oxidizers (such as chlorine, bromine and fluorine); FP (207°C, 405°F)(coal tar pitch).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health (not rated), Flammability 1, Reactivity 0; containers may explode in fire; poisonous gases are produced in fire; components (such as anthracene, phenanthrene and acridine) are volatile; contact with strong oxidizers may cause fires and explosions; use water spray to keep fire-exposed containers cool; dry chemical, carbon dioxide, or foam extinguishers may be used for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, hoarseness, coughing with phlegm, shortness of breath, nosebleeds, bronchitis, fainting, poor appetite, coma); contact (change in skin pigment, rash, brown staining in eye, inflammation of lower lip).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; perform mouth-to-mouth resuscitation if breathing has stopped; if this chemical has been swallowed, transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of nose and throat; hoarseness; cough with phlegm; shortness of breath; epistaxis (nosebleed); dizziness; headache; poor appetite; irritability; mood changes; higher levels may cause fainting or coma.

**CHRONIC HEALTH RISKS:** long-term exposure can cause change in skin pigment and rash; can cause inflammation of lower lip; repeated eye exposure can cause brown staining in the eye; has been reported to be a carcinogen in humans; has been shown to cause skin, lung, and bladder cancers; may also have the potential for causing reproductive damage in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg/m<sup>3</sup> (benzene soluble fraction); ACGIH TLV confirmed human carcinogen; OSHA PEL TWA 0.2 mg/m<sup>3</sup> (benzene-soluble fraction); NIOSH REL TWA 0.1 mg/m<sup>3</sup> (cyclohexane extractable fraction); IDLH 80 mg/m<sup>3</sup> (considered by NIOSH to be a potential occupational carcinogen).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, sleeves, apron or coveralls; materials such as nitrile and neoprene are recommended for protection against coal tar extracts; wear dust- and/or splash-proof safety goggles and face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; at concentrations above the NIOSH REL, wear self-contained breathing apparatus that has a full face-piece and is operated in positive-pressure mode; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; cautiously collect solid material and deposit in sealed containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** contain and dispose of coal tar pitch as a hazardous waste; dispose of in accordance with federal, state, and local regulations; store in tightly closed containers in a cool, well-ventilated area; separate from incompatible materials, such as strong oxidizers; keep away from sources of ignition, such as smoking and open flames.

**REGULATORY INFORMATION:** A1; A4; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used in coatings and paints, for roofing and paving, and as a binder, extender and sealant.

**KEY REFERENCES:** 4; 5; 6; 7; 15.

## **COBALT (Co, 58.93)**

**CAS/DOT IDENTIFICATION #:** 7440-48-4/variable DOT ID numbers

**SYNONYMS:** aquacat, cobalt metal dust, cobalt metal fume, super cobalt.

**PHYSICAL PROPERTIES:** steel-gray, shiny, hard metal; ductile; somewhat malleable; hydrated salts of cobalt are red; soluble salts form red solutions which become blue on adding concentrated hydrochloric acid; exists in two allotropic forms; hexagonal form is more stable than the cubic form at room temperature; readily soluble in dilute nitric acid; insoluble in water; magnetic; ferromagnetic; permeability two-thirds that of iron; MP (1493°C, 2719°F); BP (3100°C, 5612°F); DN (8.92 g/cm<sup>3</sup> at 20°C); SG (8.92); CP (0.1056 cal/g/°C at 15-100°C); LHV (1500cal/g); VP (0 mmHg at 68°F; BHN (1.25).

**CHEMICAL PROPERTIES:** stable in air or toward water at ordinary temperatures; slowly attacked by hydrochloric acid or cold sulfuric acid; corrodes readily in air; reacts with strong oxidizers or ammonium nitrate; noncombustible except in powder;  $LH_f$  (62 cal/g).

**EXPLOSION and FIRE CONCERNS:** flammable when exposed to heat or flame; powdered cobalt ignites spontaneously in air; ignites on contact with bromine pentafluoride; incandescent reaction with acetylene or nitril fluoride; explosive reaction with hydrazinium nitrate, ammonium nitrate and heat, and 1,3,4,7-tetramethylisindole (at 390°C); use agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation of dust (pulmonary symptoms; powder may cause dermatitis); ingestion of soluble salts (nausea and vomiting by local irritation).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** no data regarding humans is available.

**ACUTE HEALTH RISKS:** respiratory hypersensitivity; hemorrhage of the lung; significant decrease in ventilatory function; congestion; edema; liver and kidney damage; nausea; vomiting.

**CHRONIC HEALTH RISKS:** respiratory system effects; wheezing; asthma; pneumonia; decreased pulmonary function; fibrosis; cardiac effects; enlargement of the heart; left ventricle failure; cardiomyopathy; cardiogenic shock; kidney and liver effects; gastrointestinal effects; nausea; vomiting; diarrhea; effects on the blood; allergic dermatitis; decreased body weight; hematologic, digestive, and pulmonary changes.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (cobalt metal, dust and fume) 0.02 mg/m<sup>3</sup>; OSHA PEL TWA (cobalt metal, dust and fume) 0.1mg/m<sup>3</sup>; NIOSH REL TWA (cobalt metal, dust and fume) 0.05mg/m<sup>3</sup>; IDLH (cobalt metal, dust and fume) 20mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear protective clothing, rubber gloves and boots; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** flush liquid spills with large amounts of water and channel to a treatment system or holding tank; remove dry material by vacuuming or wet mopping.

**DISPOSAL AND STORAGE METHODS:** dig a pit, pond, lagoon, or holding area to contain liquid or solid material; seal with an impermeable flexible membrane liner; storage should be in a cool, dry, well-ventilated location; separate from strong oxidizers.

**REGULATORY INFORMATION:** Sf4.

**OTHER COMMENTS:** replaced radium in experimental medicine and cancer research; used as a trace element in fertilizers; principal use is in alloys, especially cobalt steels for permanent and soft magnets.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13.

**COKE OVEN EMISSIONS** (53% hydrogen, 26% methane, 11% nitrogen, 7% carbon monoxide, and 3% heavier hydrocarbons; formula weight is not applicable)

**CAS/DOT IDENTIFICATION #:** NA/NA

**SYNONYMS:** coke oven gas.

**PHYSICAL PROPERTIES :** mixture of coal tar, coal tar pitch, and creosote; condensed coke oven emissions consist of a brownish, thick liquid or semisolid; naphthalene-like odor is characteristic of condensed coke oven emissions; uncondensed coke oven emissions contain vapors that escape when the ovens are changed and emptied; contain chemicals such as benzo(a)pyrene, benzanthracene, chrysene, and phenanthrene; OSHA defines coke oven emissions as the benzene-soluble fraction of total particulate matter present during destructive distillation or carbonization of coal to produce coke.

**CHEMICAL PROPERTIES:** properties very depending upon the constituent.

**EXPLOSION and FIRE CONCERNS:** amount of airborne coal dust should be kept to a minimum; coal and coke dust bunkers should be fitted with explosion venting systems.

**HEALTH SYMPTOMS:** inhalation (stupor, vertigo, bronchitis, pneumoconiosis, emphysema, headache, conjunctivitis); contact (coughing, wheezing, breathing difficulties, sunburn to photosensitization of skin, skin lesions, pigmentation of the skin).

**FIRST AID:** wash eyes immediately with large amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** NA; EPA Cancer Risk Level (1 in a million excess lifetime risk):  $2 \times 10^{-6}$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes and respiratory system; irritation of the mucosa; headache; stupor; dizziness; coughing; sputum production; wheezing; dyspnea; heat cramps; cessation of respiration; loss of consciousness.

**CHRONIC HEALTH RISKS:** pneumoconiosis (dust in the lungs); emphysema; bronchitis; lesions of the respiratory and digestive systems; increase in cancer of the lungs, kidney, trachea, bronchus, and prostate; severe dermatitis; skin lesions; disfiguring pigmentation of the skin; conjunctivitis; other skin disorders such as folliculitis, furunculosis, erythema, photosensitivity, melanosis, and warts; EPA Group A: classifiable as a human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV (coal tar pitch volatiles, benzene soluble) 0.2 mg/m<sup>3</sup>; OSHA PEL (coal tar pitch volatiles, benzene soluble) 0.2 mg/m<sup>3</sup>; OSHA TLV (coke oven emissions) 0.150 mg/m<sup>3</sup>; NIOSH REL (coal tar pitch volatiles, benzo(a)pyrene) 0.1 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** use asbestos protective clothing and face protection; flame-resistant gloves are also recommended, as well as flame retardant jackets and pants; use insulated footwear and safety shoes; wear protective helmets and vented safety goggles; workers should be supplied with appropriate respiratory equipment.

**SPILL CLEAN-UP:** use engineering controls and work practices as soon as possible; clean coke oven doors before each charge to make sure there is a metal-to-metal fit during coking to prevent emissions from leaking out; cut off gas supply by purging pipes with steam or an inert gas.

**DISPOSAL AND STORAGE METHODS:** Carcinogen Assessment Group at EPA had designated sludge from coking operations as a potential carcinogen, and these sludges are regulated under the hazardous waste disposal rule of the Resource Conservation and Recovery Act (RCRA).

**REGULATORY INFORMATION:** CA2; Sfl; Reportable Quantity (RQ): 1 lb (0.454kg); A1; A4; CAL; DOT hazard class/division (forbidden).

**OTHER COMMENTS:** primary use is in the extraction of metals from their ores, especially iron; used to synthesize calcium carbide; used in the manufacture of graphite and electrodes; coal tar is used in the clinical treatment of skin disorders such as dermatitis, eczema and psoriasis.

**KEY REFERENCES:** 4; 5; 7; 13; 16; 19.

### **COPPER (Cu, 63.54)**

**CAS/DOT IDENTIFICATION #:** 7440-50-8/none

**SYNONYMS:** arwood copper, bronze powder, C.I. 77400, copper bronze, copper metal dusts, copper metal mists, raney copper.

**PHYSICAL PROPERTIES :** reddish solid; lustrous, ductile, and malleable metal; face-centered cubic (fcc) structure; becomes dull upon exposure to air; becomes coated with a green layer of basic carbonate in moist air; odorless solid; slowly soluble in ammonia water; soluble in nitric acid, hot concentrated sulfuric acid, and hydrogen bromide; very slightly soluble in hydrochloric acid and ammonium hydroxide; insoluble in hot and cold water; copper fume is characterized by finely divided black particulates dispersed in air; MP (1083°C, 1981°F); BP (2595°C, 4703°F); DN (8.94 g/cm<sup>3</sup>); SG (8.94); CP (0.092 cal/g/°C solid at 20° C, 0.112 cal/g/°C liquid at 20°C); HV (1150 cal/g); VD (NA); VP (0 mmHg approximately); MOHS' HARDNESS (3.0).

**CHEMICAL PROPERTIES:** stable in air; stable under ordinary conditions of use and storage; hazardous polymerization will not occur; more resistant to atmospheric corrosion than iron; readily attacked by dilute nitric acid, hot concentrated sulfuric acid, and hydrobromic acid; very slowly attacked by cold hydrochloric acid and dilute sulfuric acid; also attacked by acetic and other organic acids; excellent conductor of electricity; a complexing agent; FP (NA); LFL/UFL (NA); AT (NA); H<sub>f</sub> (13.26 kJ/mol at 1357.77K); RES (1.673 microhm/cm).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid in bulk form; powdered form may ignite; not expected to be a fire hazard; dust may form explosive mixtures with air; on long standing a white deposit may form, which is a readily explosive peroxide; liquid copper explodes on contact with water; violent reaction with ethyne (acetylene), bromates, chlorates, iodates, ethylene oxide, hydrogen peroxide, hydrazine mononitrate, hydrazoic acid, lead azide, potassium peroxide, sodium peroxide, sodium azide, sulfuric acid, hydrogen sulfide, and air, and dimethyl sulfoxide and trichloroacetic acid; reacts explosively with acetylenic compounds, 3-bromopropyne, lead azide, ethylene oxide, and ammonium nitrate; ignites on contact with chlorine trifluoride, chlorine, fluorine (above 121°C), and hydrazinium nitrate (above 70°C); incandescent reaction with potassium dioxide; incompatible with strong oxidizing agents, strong acids, strong bases, acetylene, acetaldehyde, magnesium, and 1-bromo-2-propyne; hazardous decomposition products include copper fumes; use extinguishing media appropriate for firefighting purposes; application of water to hot metal may generate steam.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract, headache, nausea, vomiting, diarrhea, chills, fever, aching muscles); contact (irritation of eyes and skin, dermatitis, skin discoloration, metallic or sweet taste); ingestion (nausea, vomiting, diarrhea).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if swallowed, induce vomiting immediately and get medical personnel.

**HUMAN TOXICITY DATA:** oral-human TDLo 120µg/kg; toxic effect: gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and pharynx; irritation of upper respiratory tract; nasal perforation; metallic taste; discoloration of skin and hair; metal fume fever: chills, muscle ache, fever, nausea, vomiting, diarrhea, dry throat, cough, weakness, lassitude.

**CHRONIC HEALTH RISKS:** damage to liver and lungs; kidney damage; anemia; may possibly cause reproductive effects; chronic exposure may cause tissue damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg(dust mist as Cu)/m<sup>3</sup>; ACGIH TLV TWA 0.2 mg (fume as Cu)/m<sup>3</sup>; OSHA PEL TWA 1 mg(dust mist as Cu)/m<sup>3</sup>; OSHA PEL TWA 0.1 mg (fume as Cu)/m<sup>3</sup>; NIOSH REL TWA 1 mg(dust mist as Cu)/m<sup>3</sup>; NIOSH REL TWA 0.1 mg (fume, as Cu)/m<sup>3</sup>; IDLH 100 mg(Cu)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; use dust- and/or splash-proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; wear self-contained breathing apparatus operated in positive pressure mode; maintain eye-wash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; carefully sweep up spilled material and remove to a secure sanitary landfill; liquid containing copper may be absorbed in dry sand or other inert material (copper dusts and mists).

**DISPOSAL AND STORAGE METHODS:** route to metal salvage facility; manage whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated area; keep in tightly closed containers; suitable for any general chemical storage area.

**REGULATORY INFORMATION:** S1; S51; S80; S82; S3'; F2; R2-8; Reportable Quantity (RQ): 5000 lbs (2270 kg); Sf1; Sf3; CW5; CAL.

**OTHER COMMENTS:** used in the manufacture of bronzes, brass, and other copper alloys; useful in the manufacture of electric wiring, electrical conductors, switches, and ammunition; electroplated protective coatings and undercoats for nickel, chromium, zinc, etc.; used in corrosion-resistant piping; has also been used in cement, food, drugs, metallurgy, nylon, paper products, pigments, and dyes; use as a pollution control catalyst.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

**COTTON DUST (Molecular formula: not applicable, Formula weight: unknown)**

**CAS/DOT IDENTIFICATION #:** none/none

**SYNONYMS:** raw cotton dust.

**PHYSICAL PROPERTIES:** colorless solid or fibers; no characteristic odor; insoluble in water; MP (decomposes); BP (decomposes); DN/SG (unknown); VS (unknown); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; considered to be an inert dust; can react with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HC (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible solid; moderate fire and explosion hazard; NFPA rating (not rated); synthetic content may produce irritating smoke; incompatible with oxidizing materials; no hazardous decomposition products have been reported; any class "A" fire extinguishing media may be used for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (chest tightness, cough, wheezing, breathing difficulty, bronchitis, sneezing, conjunctivitis, upper respiratory symptoms).

**FIRST AID:** no emergency or first aid procedures have been listed in the literature; after breathing in large amounts of this chemical, move exposed person to fresh air promptly.

**HUMAN TOXICITY DATA:** inhalation – human TCLo 10,000 mg/m<sup>3</sup>/10Y; toxic effect: pulmonary effects; no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** byssinosis; transient chest tightness; cough; wheezing dyspnea (breathing difficulty); decreased forced expiratory volume; bronchitis; fever; chills upper respiratory symptoms after initial exposure; malaise (vague feeling of discomfort); conjunctivitis or blepharitis from the burned products of the gassing of the double yarn.

**CHRONIC HEALTH RISKS:** a mild allergen; may produce bronchial asthma; sneezing and eczema in sensitized persons; sensitive person with existing severe obstructive lung disease may be affected adversely.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg/m<sup>3</sup> (raw dust); OSHA PEL TWA 1 mg/m<sup>3</sup> (raw dust), 0.2 mg/m<sup>3</sup> (yarn manufacturing), 0.75 mg/m<sup>3</sup> (slashing and weaving), 0.5 mg/m<sup>3</sup> (other operations); NIOSH REL TWA < 0.200 mg/m<sup>3</sup> (as lint-free cotton dust); IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear clean-body covering clothing, and protective gloves; use dust-proof safety goggles; enclose operations and/or provide local exhaust ventilation at the site of chemical release; appropriate respirators are needed in areas where exposures are above 1.0 mg/m<sup>3</sup>; in unknown concentrations or IDLH conditions, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** collect spilled material and deposit in sealed containers; if appropriate, moisten material with water in order to avoid dust generation.

**DISPOSAL AND STORAGE METHODS:** no special procedures are required for disposal of this chemical; discard with other plant solid waste; storage should be in sealable containers at room temperature; use only with adequate ventilation.

**REGULATORY INFORMATION:** A1; A4; DOT hazard class/division (none); label (none).

**OTHER COMMENTS:** used in the manufacture of apparel, industrial and household fabrics, upholstery, medicine, and thread.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

**CRAG HERBICIDE (C<sub>8</sub>H<sub>7</sub>Cl<sub>2</sub>NaO<sub>5</sub>S, 309.10)****CAS/DOT IDENTIFICATION #:** 136-78-7/none

**SYNONYMS:** crag sesone, 2-(2,4-dichlorophenoxy) ethanol hydrogen sulfate sodium salt, disul-sodium, sesone, sodium-2,4-dichlorophenoxyethylsulfate, sodium-2,4-dichlorophenyl cellosolve sulfate.

**PHYSICAL PROPERTIES :** colorless to white crystalline solid; odorless; very soluble in water; insoluble in most organic solvents except methanol; MP (245°C, 473°F decomposes); BP (decomposes); DN (1.70 g/cm<sup>3</sup> at 20°C); SG (1.70); VD (NA); VP (0.1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; not combustible; gives off irritating or toxic fumes (or gases) in a fire; can react vigorously with acids and strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HF (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); evaporation at 20°C is negligible; a nuisance-causing concentration of airborne particles can be reached rapidly on spraying or dispersion, especially if powdered; decomposes on heating, producing very toxic fumes of hydrogen chloride, sodium oxide, and oxides of sulfur; in case of fire in the surroundings, all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, sore throat, irritates eyes, skin and respiratory tract); skin/eye contact (redness, pain); ingestion (burning sensation, liver and kidney damage).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of water or shower; if breathing is difficult, remove to fresh air and provide oxygen; administer artificial respiration if not breathing; if swallowed, get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; cough; sore throat; burning sensation; may cause effects on the kidneys and liver; may cause convulsions and central nervous system effects in animals.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>; 5 mg (respirable dust)/m<sup>3</sup>; NIOSH REL TWA 10mg (total dust)/m<sup>3</sup>; 5 mg(respirable dust)/m<sup>3</sup>; IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear chemical safety goggles in combination with breathing protection if powder; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; wear self-contained breathing apparatus in oxygen deficient atmospheres; for extra personal protection, a P2 filter respirator for harmful particles should be employed; maintain eyewash fountains and quick drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; if appropriate, moisten first to prevent dusting; collect remainder, then remove to safe place; do not wash away into sewer.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an appropriate hazardous waste disposal facility; dispose of container and unused contents in accordance with federal, state, and local requirements; store in a cool, dry, well-ventilated location; separate from strong oxidants, acids, food and feedstuffs.

**REGULATORY INFORMATION:** F2; F4; A1; CAL.

**OTHER COMMENTS:** used as an herbicide; poisonous by ingestion; substance is metabolized in the body into 2,4-D (Dichlorophenoxyacetic acid); physical and toxicological properties may change due to carrier solvents used in commercial formulations.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### **CRESOLS (CH<sub>3</sub>C<sub>6</sub>H<sub>4</sub>OH, 108.15)**

**CAS/DOT IDENTIFICATION #:** 1319-77-3/UN2076

**SYNONYMS:** ortho-, meta-, para-cresylic acid, 2-,3-, or 4-hydroxytoluene, 2-, 3-, or 4-methylphenol.

**PHYSICAL PROPERTIES:** colorless crystals; brownish-yellow or pinkish liquid; crystals or liquid darken with exposure to air and light; phenolic odor; miscible with ethyl alcohol, benzene, ether, glycerol, and petroleum ether; soluble in vegetable oils, glycol, and solutions of alkali hydroxides; not soluble in water; MP (10.9-35.5°C, 51.6-96°F); BP (191-202.8°C, 375.8-397°F); DN (1.030-1.038 g/cm<sup>3</sup> at 25°C); SG (1.03-1.05 at 20°C); VS (4.49-7.0 cP at 40°C); HV (200 Btu/lb, 100cal/g, 4.6 x 10<sup>5</sup> J/kg); VD (3.72); VP (1 mmHg at 38-53°C); OT (0.00028ppm).

**CHEMICAL PROPERTIES:** reacts with strong oxidizers and acids; FP (81-86°C, 178-187°F); LFL/UFL (1.1-1.4%, NA); AT (558-599°C, 1038-1100°F); HC (-14720 to -14740 Btu/lb, -8180 to -8190 cal/g, -342.5 to -342.9 x 10<sup>5</sup> J/kg); LH<sub>f</sub> (3095 cal/gmol).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; flammable when exposed to heat or flame; NFPA rating Health 3, Flammability 2, Reactivity 0; explosive in vapor form when exposed to heat, flame, and other ignition sources; reacts violently with nitric acid, oleum or chlorosulfonic acid; incompatible with strong oxidizing agents; products of combustion include highly toxic and irritating fumes of cresols and other aromatic products; use water spray, alcohol foam, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of nose, throat, and eyes); skin contact (intense burning, loss of feeling, white discoloration, softening, gangrene); ingestion (burning sensation in mouth and esophagus, vomiting).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** ortho-cresol, meta-cresol reference dose 0.05 (mg/kg)day; target organs: nasal septum, respiratory system, liver, eyes, kidneys, and skin.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and mucous membranes; burns to mouth and throat; lesions of the mouth and esophagus; digestive tract bleeding; pulmonary edema; headache; vomiting; nausea; dizziness; confusion; drowsiness; unconsciousness; weak pulse; vascular collapse; dyspnea.

**CHRONIC HEALTH RISKS:** central nervous system depression; pancreas damage; damage to lungs, kidneys, and liver; effects on blood system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5ppm (skin); OSHA PEL TWA 5ppm (22mg/m<sup>3</sup>)(skin); NIOSH REL TWA 2.3ppm (10mg/m<sup>3</sup>); IDLH 250ppm.

**PERSONAL PROTECTION:** wear special protective clothing, i.e., rubber coveralls/apron, rubber shoes or boots; wear chemical safety glasses; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** approach from upwind; contain spill and dispose of properly; if dissolved, absorb as much as possible with materials such as dry earth or activated carbon; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb with activated carbon and use mechanical lifts to remove immobilized masses of pollutants and precipitates; place in a secured, sanitary landfill; store in a cool, dry, well-ventilated location; isolate from oxidizing materials.

**REGULATORY INFORMATION:** Sf3; Reportable Quantity (RQ): 100lbs (45.4kg); A1; CAL; DOT hazard class/division (6.1); labels (poison, corrosive).

**OTHER COMMENTS:** used in many household disinfecting solutions; used for making synthetic resins; used as an additive to lubrication oils; wide use as a degreasing agent.

**KEY REFERENCES:** 4; 5; 6; 10; 11; 12; 13; 14.

### **CROTONALDEHYDE (C<sub>4</sub>H<sub>6</sub>O, 70.09).**

**CAS/DOT IDENTIFICATION #:** 123-73-9 OR 4170-30-3/UN1143

**SYNONYMS:** 2-butenal, beta-methylacrolein

**PHYSICAL PROPERTIES:** water-white, mobile liquid; suffocating odor; turns pale-yellow on exposure to light and air; liquid is lighter than water; vapor is heavier than air; solid phase separates out at -5°C (23°F); very soluble in water; miscible in all proportions with ether, alcohol, toluene, benzene, gasoline, kerosene, and solvent naphtha; MP((trans)-76.5°C, -105.7°F; (cis) -69°C, -92°F); BP(104°C, 219°F); DN(0.8530 g/mL at 20°C); LSG(0.85); CP(0.7 cal/g°C liquid at 25°C); HV(8.62 cal/mole); VD(2.41); VP(19 mmHg at 20°C); OT(2.10x10<sup>-2</sup> mg/L of chemically pure gas in air).

**CHEMICAL PROPERTIES:** stabilized under ordinary conditions of use and storage; commercial grade (93%) is stabilized with water, by which a solid phase separates out at -5°C (23°F); hazardous polymerization may occur; when pure, readily resinifies to a dimer; slowly oxidizes to crotonic acid; a strong reducing agent; can react vigorously with oxidizing materials; FP(13°C, 55°F); LFL/UFL (2.1%, 15.5%); AT (232.2°C, 450°F); HC(2,268 kJ/mol); HF(-138.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 3, Flammability 3, Reactivity 2; may form explosive vapor/air mixtures above the flash point; flashback along vapor trail may occur; closed containers may explode violently upon heating; may form explosive peroxides; may polymerize due to elevated temperatures and under the influence of alkalis, causing fire and explosion hazard; attacks plastics and many other substances; violent reaction with 1,3-butadiene; ignites spontaneously on contact with concentrated nitric

acid; reacts violently with many oxidants; hazardous decomposition products include carbon monoxide and carbon dioxide; use water spray, dry chemical, carbon dioxide, or alcohol-resistant foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, chest pain, labored breathing, shortness of breath, sore throat, burning sensation, nausea, vomiting, collapse, loss of consciousness); eye/skin contact (severe deep burns, systemic illnesses); ingestion (abdominal pain, nausea, vomiting, burning sensation, shock or collapse).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** eye-human 45 ppm; inhalation-human TCLO 12 mg/m<sup>3</sup>/10M; toxic effect: irritant effects.

**ACUTE HEALTH RISKS:** irritation to skin, eyes, and respiratory tract; irritation of mucous membranes; lacrimation; corneal burns; cough; sore throat; chest pain; shortness of breath; labored breathing; nausea; vomiting; abdominal pain; burning sensation; shock or collapse; may cause impaired lung function; death in high concentrations.

**CHRONIC HEALTH RISKS:** a chronic allergen; toxic effects are unknown.

**EXPOSURE GUIDELINES:** ACGIH TLV 2 ppm (5.7 mg/m<sup>3</sup>); OSHA PEL TWA 2 ppm (6 mg/m<sup>3</sup>); NIOSH REL TWA 2 ppm (6 mg/m<sup>3</sup>); IDLH 50 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including chemical-resistant gloves; wear splash-proof safety goggles and self-contained breathing apparatus; enclose operations and/or use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment and lighting; compressed air may not be used for filling, discharging, or handling; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and disperse vapors; collect spilled liquid in sealable containers or absorb in sand or inert absorbent; flush remainder with large amounts of water but not into confined spaces such as sewers due to possibility of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured sanitary landfill; atomize large quantities in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; store in a cool, dry location; use only with adequate ventilation; keep in the dark; store only if stabilized; outside storage is preferred; inside storage should be in a standard flammable liquids storage room or cabinet; separate from strong oxidants, alkalies, food and feedstuffs.

**REGULATORY INFORMATION:** R4; U waste # (U053); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sfl; Sf2; Sf3; Cw1; CW2; T799-5000; A1; CAL; DOT hazard class/division (6.1); labels (flammable liquid and poison).

**OTHER COMMENTS:** used as a chemical intermediate in the manufacture of butyl alcohol, butyraldehyde, maleic acid, crotyl alcohol, sorbic acid, crotonic acid, and 2-ethylhexyl alcohol; minor amounts are used in the preparation of rubber accelerators; utilized as a solvent in purification of lubricating oils, and in the manufacture of insecticides, rubber antioxidants and resins.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 11; 12; 14.

**CUMENE (C<sub>9</sub>H<sub>12</sub>, 120.21)****CAS/DOT IDENTIFICATION #:** 98-82-8/UN1918**SYNONYMS:** cumol, isopropyl benzene, 2-phenylpropane.

**PHYSICAL PROPERTIES :** colorless liquid; sharp, penetrating, gasoline-like odor; soluble in ethyl alcohol, ether, and benzene; not soluble in water; MP (-96°C, -141°F); BP (152°C, 306°F); DN (0.864 g/cm<sup>3</sup> at 20°C); LSG (0.86); ST (28.2 dynes/cm at 20°C); VS (0.8 cP at 20°C); CP (0.46cal/g-°C at 25°C); HV (10,335.3 gcal/gmol); VP (3.2 mmHg at 20°C, 10mmHg at 38.3°C); OT (0.012ppm, 0.06mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** volatile; reacts with strong oxidizer, nitric acid, and sulfuric acid; forms cumene hydroperoxide upon long exposure to air; FP (33°C, 92°F); LFL/UFL (0.9%, 6.5%); AT (425°C, 797°F); HC (1247.3 kcal/mol at 20°C); HF (-9.9 kcal/mol at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 1; reacts violently with nitric acid, oleum and chlorosulfonic acid; may accumulate static electricity; forms explosive peroxides; incompatible with oxidizing agents; combustion may produce hazardous by-products, such as carbon monoxide or carbon dioxide; use carbon dioxide, dry chemical powder, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); skin absorption (headache, narcotic effects).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 200ppm; toxic effects: nose, central nervous system, pulmonary system; human adverse reflex response 0.028mg/m<sup>3</sup>; reference concentration 0.009mg/m<sup>3</sup>; reference dose 0.04(mg/kg)/day.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and mucous membranes; irritation of upper respiratory tract; headache; dermatitis; narcotic effects; coma.

**CHRONIC HEALTH RISKS:** central nervous system depression; damage to lungs; liver damage; kidney damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50ppm (skin); OSHA PEL TWA 50ppm (245mg/m<sup>3</sup>)(skin); NIOSH REL TWA 50ppm (245mg/m<sup>3</sup>)(skin); IDLH 900ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb in noncombustible material and dispose of properly; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** mix with a flammable solvent (such as alcohol) and burn in chemical incinerator equipped with afterburner and scrubber; store in a cool, dry location; outside storage preferred; inside storage should be in a standard flammable liquids storage room or cabinet; isolate from oxidizing materials, nitric acid and sulfuric acid.

**REGULATORY INFORMATION:** CA2; R6; U waste #(U055); Reportable Quantity (RQ): 5000lbs (2270kg); Sf1; Sf3; T120-a; T799-18; A1; CAL; DOT hazard class/division (3); labels (flammable, combustible).

**OTHER COMMENTS:** used as a thinner for paints and enamels; used as a constituent of naphtha; used as a component of high octane aviation fuel; used in gasoline blending.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14.

**CYANIDES (as CN)** (Cyanides have variable molecular formulas. The molecular formulas for potassium cyanide is KCN. The molecular formula for sodium cyanide is NaCN. Cyanides have variable formula weights. The formula weight for potassium cyanide is 65.12. The formula weight for sodium cyanide is 49.01.)

**CAS/DOT IDENTIFICATION #:** Cyanides have variable CAS #s. THE CAS# for potassium cyanide is 151-50-8. The CAS # for sodium cyanide is 143-33-9. Cyanides have variable DOT identification numbers. The DOT identification numbers for potassium cyanide and sodium cyanide are UN1680 and UN1689, respectively.

**SYNONYMS:** (potassium cyanide) cyanide of potassium, hydrocyanic acid potassium salt. (sodium cyanides) cyanide of sodium, hydrocyanic acid sodium salt, prussiate of soda.

**PHYSICAL PROPERTIES :** (potassium cyanide) white lumps or deliquescent, colorless cubic crystals; faint, almond-like odor; undergoes cubic to orthorhombic transition at minus degrees; very soluble in water; slightly soluble in alcohol and glycerol; MP (634.5°C, 1174°F); BP (1625°C, 2957°F); DN (1.553 g/cm<sup>3</sup> at 20°C); SG (1.55); VD (NA); VP (approximately 0 mmHg at 20°C). (sodium cyanide) white, granular powder or deliquescent, cubic crystals; faint, almond-like odor; undergoes cubic to hexagonal transition on cooling below 10°C (50°F); very soluble in water; slightly soluble in ethanol and formamide; MP (564°C, 1047°F); BP (1496°C, 2725°F); DN (1.60 g/cm<sup>3</sup> at 20°C); SG (1.6); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** (potassium cyanide) stable under ordinary conditions of use and storage; aqueous solution is strongly alkaline and decomposes rapidly on standing; gradually decomposed by carbon dioxide and moisture on exposure to air; absorbs moisture from the air, forming a syrup; very corrosive; reacts with water or any acid to produce hydrogen cyanide; FP (NA); LFL/UFL (NA); AT (NA); HC (NA). (sodium cyanide) stable under ordinary conditions of use and storage; aqueous solution is strongly alkaline and decomposes rapidly on standing; reacts with acid to release hydrogen cyanide gas; absorbs moisture from the air, forming a syrup; solution readily dissolves gold and silver in presence of air; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; contact with acids release highly flammable hydrogen cyanide gas; flammable by chemical reaction with heat and moisture; NFPA rating Health 3, Flammability 0, Reactivity 0; react violently with hypochlorite solutions at pH 10.0-10.3; many organic nitriles may be very reactive; n-cyano derivative may be reactive or unstable; cyanide solutions liberate hydrogen cyanide on exposure to carbon dioxide from air; metal cyanides may be thermally unstable and are easily oxidized; violent reaction with fluorine, magnesium, nitrates, chlorate, nitric acid and acid salts; explosion results when melted with nitrates or chlorate at about 450°C (842°F); heating to decomposition or contact with acid, acid fumes, water or steam, emits toxic gases and vapors (such as hydrogen cyanide and carbon monoxide); smother fire with dry sand, dry clay or dry ground limestone; carbon dioxide, halogenated extinguishing agents or water should not be used for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (difficulty breathing, irregular heartbeat, uncontrolled movement, convulsions, pain in the heart area, vomiting, blood changes, headache, enlarged thyroid glands, possible death); skin contact (irritates skin, may cause sores); ingestion (salivation, rapid breathing, low blood pressure, nausea, vomiting, shortness of breath, high cya-

nide levels in blood, nerve damage, anxiety, giddiness, paralysis, cardiac arrhythmias, transient respiratory stimulation, lower jaw stiffness).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, give large quantities of water to drink; after the water has been swallowed, induce vomiting and seek medical attention.

**HUMAN TOXICITY DATA:** (potassium cyanide) oral-human LDLo 2857 µg/kg; oral-woman TDLo 100mg/kg; toxic effect: central nervous system, pulmonary effects; oral-man TDLo 13,699µg/kg. (sodium cyanide) oral-human LDLo 2857µg/kg; oral-man TDLo 714 µg/kg; toxic effect: central nervous system; oral-man LDLo 6557 µg/kg; toxic effect: central nervous system, gastrointestinal tract; unreported-man LDLo 2206 µg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory system; weakness; headache; confusion; anxiety; vertigo; dizziness; giddiness; nausea; vomiting; increased rate of respiration; slow, gasping respiration; shortness of breath; rapid, deep breathing; salivation; lower jaw stiffness; cardiac arrhythmias; affects central nervous system; effects on the brain, lungs, and heart; paralysis; bradycardia; convulsions; loss of consciousness; coma; harmful to cardiovascular system.

**CHRONIC HEALTH RISKS:** headaches; numbness; weakness; dizziness; tremors; loss of appetite; effects on central nervous system; deafness; loss of muscle coordination; loss of visual acuity; respiratory effects; cardiovascular effects; cretinism; enlarged thyroid gland; congenital hypothyroidism in newborns; malformation in fetus; low fetal body weights in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm; OSHA PEL TWA 5 mg(CN)/m<sup>3</sup>; NIOSH REL CL 5 mg(CN)/m<sup>3</sup>/10m (4.7 ppm/10M); IDLH 25 mg(CN)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, and gas-tight suit; wear dust- and splash-proof safety goggles; a closed system of local exhaust ventilation is required to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear positive-pressure self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eyewash baths or safety showers in work area..

**SPILL CLEAN-UP:** ventilate area of spill; spills should be promptly and carefully cleaned up by shoveling the material into a suitable dry container; any dispersal of dust into the air should be minimized; keep water away from release.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in a secured, sanitary landfill; liquid containing cyanides can be dissolved in flammable solvents and sprayed into an incinerator equipped with afterburner and scrubber; store in a cool, dry location; use only with adequate ventilation; separate from acids, water, and carbon dioxide.

**REGULATORY INFORMATION:** Sfl.

**OTHER COMMENTS:** used as pesticides and fumigants; used in metal treatment, including nitriding, tempering, cleaning and coating; used as a chemical intermediate in the manufacture of pharmaceuticals, dyes, vitamins, and plastics, utilized during chemical synthesis of nitriles, carbylamines, cyano fatty acids, and inorganic cyanides; other uses include cellulose technology, paper manufacture, cement stabilizers, photography, blueprinting and engraving.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 14; 16; 19.

**CYCLOHEXANE (C<sub>6</sub>H<sub>12</sub>, 84.18)****CAS/DOT IDENTIFICATION #:** 110-82-7/UN1145**SYNONYMS:** benzene hexahydride, hexahydrobenzene, hexamethylene, hexanaphthene.**PHYSICAL PROPERTIES :** colorless, mobile liquid; pungent odor when impure; sweet, chloroform-like odor; a solid below 44°F; miscible with ethanol, ethyl ether, acetone, benzene, and carbon tetrachloride; miscible with olive oil; insoluble in water; soluble in methanol; MP (6.47°C, 43.64°F); BP (80.7°C, 177.3°F at 760 mmHg); DN (0.7791 g/mL at 20°C); LSG (0.78); ST (24.6 dynes/cm at 20°C); VS (1.02 cP at 17°C); CP (154.9 J/K-mol liquid at 25°C); HV (33.01 kJ/mol at 25°C); VD (2.90); VP (100 mmHg at 60.8°C); OT (300ppm).**CHEMICAL PROPERTIES:** flammable liquid; non-corrosive; about one-third the volatility of ether at room temperature; can react with oxidizing materials; FP (-18.3°C, -1°F); LFL/UFL (1.3%, 8.4%); AT (245°C, 473°F); HC (936.87 kcal/g); HF (-156.4kJ/mol liquid at 25°C).**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; dangerous fire hazard when exposed to heat, flame, or oxidizers; moderate explosion hazard in vapor form; flashback along vapor trail may occur; vapor may explode on ignition in a confined area; explosion can result when mixed hot with liquid dinitrogen tetraoxide; will volatilize quickly; may be quite persistent; low solubility suggests small explosive hazard in boiler feed water, but may result in reduced heat transfer, hot spots, or scaling; heating to decomposition emits irritating smoke and fumes; use foam, dry chemical, or carbon dioxide for firefighting purposes.**HEALTH SYMPTOMS:** inhalation (difficulty breathing, dizziness, loss of consciousness, irritates eyes, nose, and throat); ingestion (nausea, vomiting); contact (irritates skin and eyes, dermatitis).**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.**HUMAN TOXICITY DATA:** unscheduled DNA synthesis-human lymphocyte cell culture; negative results at  $1 \times 10^{-2}$ ,  $1 \times 10^{-3}$ ,  $1 \times 10^{-4}$  M cyclohexane.**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; dizziness; nausea; vomiting; drowsiness; difficult breathing; loss of consciousness; collapse; narcosis.**CHRONIC HEALTH RISKS:** central nervous system effects; dermatitis.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 300 ppm; OSHA PEL TWA 300 ppm (1050mg/m<sup>3</sup>); NIOSH REL TWA 300ppm (1050 mg/m<sup>3</sup>); IDLH 1300 ppm.**PERSONAL PROTECTION:** wear full protective clothing and self-contained breathing apparatus; hand and arm protection should be worn; chemical safety goggles are recommended where there is a danger of splashes or prolonged skin contact.**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; absorb as much as possible with materials such as dry earth or sand; flush remaining cyclohexane with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; atomize large amounts in a suitable combustion chamber; dissolve in additional flammable solvent and burn in incinerator under controlled conditions; store in a cool, dry location with adequate ventilation; outside storage preferred; inside should be in a standard flammable liquids storage room or cabinet.

**REGULATORY INFORMATION:** U waste # (U056); Reportable Quantity (RQ): 1000 lbs (454kg); Sf1; Sf3; CW1; CW2; T120-a; T799-5000; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose ethers, fats, oils, waxes, bitumens, resins, lacquers, and crude rubber; paint and varnish remover; used in the manufacture of adipic acid, benzene, cyclohexyl chloride, nitrocyclohexane, cyclohexanol, and cyclohexanone; useful in the manufacture of nylon and solid fuels; may also be used in the industrial recrystallization of steroids.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 11; 12; 14.

### **CYCLOHEXANOL (C<sub>6</sub>H<sub>11</sub>OH, 100.16)**

**CAS/DOT IDENTIFICATION #:** 108-93-0/UN1993

**SYNONYMS:** anol, cyclohexyl alcohol, hexahydrophenol, hexalin, hydralin, hydroxycyclohexane.

**PHYSICAL PROPERTIES :** sticky solid or colorless to light-yellow, viscous liquid; hygroscopic; camphor-like odor; miscible with ethanol, ethyl acetate, linseed oil, petroleum solvents, and aromatic hydrocarbons; sparingly soluble in water; MP (23-25°C, 73-77°F); BP (161.5°C, 323°F); DN (0.9624 g/mL at 20°C); LSG (0.96); ST (32.92 mN/m at 298.15K); CP (208.2 J/K-mol liquid at 298.15K); HV (62.01 kJ/mol at 298.15K); VD (3.45); VP (1 mmHg at 21.0°C); OT (160 ppm in air).

**CHEMICAL PROPERTIES:** combustible liquid; can react with oxidizing materials, such as nitric acid and hydrogen peroxide; FP (67.7°C, 154°F); LFL/UFL (NA); AT (300°C, 572°F); HC (-8910 cal/g, -373 x 10<sup>5</sup> J/kg); HF (-348.2 kJ/mol liquid at 298.15K); H<sub>f</sub> (1.76 kJ/mol at 298.61K).

**EXPLOSION and FIRE CONCERNS:** combustible; flammable when exposed to heat or flame; NFPA rating Health 1, Flammability 2, Reactivity 0; can react vigorously with oxidizing materials; reacts violently with nitric acid at room temperature to form an explosive product; ignites on contact with chromium trioxide; incompatible with oxidants; heating to decomposition emits smoke and fumes; use alcohol foam, dry chemical, water spray, or carbon dioxide for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, narcotic effects, changes in respiratory systems, attacks liver, kidneys, and vascular system).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** eye-human 100 ppm; cytogenetic analysis-human leukocyte 100µmol/L; inhalation-human TCLo 75 ppm; toxic effect: nose, eye, pulmonary effects.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, throat, and skin; narcosis-depression of central nervous system; sleepiness; loss of consciousness.

**CHRONIC HEALTH RISKS:** damage to kidneys and liver; injury to the vascular system; changes in olfactory and respiratory systems; may alter genetic material.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (skin); OSHA PEL TWA 50 ppm (200 mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (200 mg/m<sup>3</sup>)(skin); IDLH 400 ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear rubber over-clothing, including gloves; wear splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; use water spray to cool and disperse vapors; water spray may be used to flush spills away and to dilute them, but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** atomize large amounts in a suitable combustion chamber; dissolve in a more flammable solvent (such as alcohol) and burn in incinerator equipped with an appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; should be kept well separated from oxidizing agents (nitrates, peroxides, etc.); should not be stored near combustible materials.

**REGULATORY INFORMATION:** Sf3; A1; CAL.

**OTHER COMMENTS:** used in the manufacture of soap to incorporate solvents and phenolic insecticides; useful as a solvent for oils, shellac, acid dyes, metallic soaps, gums, and natural resins; source of adipic acid for nylon; used in fragrances; dry cleaning, textile cleaning, lacquers, paints, varnishes, polishes, plasticizers, laundry and household preparations.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 11; 14; 16.

### CYCLOHEXANONE (C<sub>6</sub>H<sub>10</sub>O, 98.16)

**CAS/DOT IDENTIFICATION #:** 108-94-1/UN1915

**SYNONYMS:** anone, cyclohexyl ketone, hytrol o, ketohexamethylene, nadone, pimelic ketone, sextone.

**PHYSICAL PROPERTIES :** water-white to pale-yellow, oily liquid; peppermint- or acetone-like odor; soluble in alcohol, ether, and in most common organic solvents; slightly soluble in water; MP (-45.0°C, -49°F); BP (155.6°C, 312°F at 760 mmHg); DN (0.9478 g/mL at 20°C); LSG (0.95); ST (34.57 mN/m at 298.15K); VS (2.017 mPa-s at 298.15K); CP (182.2 J/K-mol liquid at 298.15K); HV (45.06 kJ/mol at 298.15K); VD (3.4); VP (10mmHg at 38.7°C); OT(NA).

**CHEMICAL PROPERTIES:** combustible liquid; can react vigorously with oxidizing materials; reacts with nitric acid and hydrogen peroxide; FP (44°C, 111°F); LFL/UFL (1.1% at 212°F, 9.4%); AT (420°C, 788°F); HC (-3.299 x 10<sup>9</sup> J/kmol); HF (-271.2 kJ/mol liquid at 298.15K).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 1, Flammability 2, Reactivity 0; flammable liquid when exposed to heat or flame; slightly explosive when exposed to flame in its vapor form; reacts explosively with nitric acid at 75°C; reaction with

nitric acid and hydrogen peroxide forms an explosive peroxide; can react vigorously with oxidizing materials heating to decomposition emits acrid smoke and irritating fumes; use alcohol foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, changes in the sense of smell, respiratory changes, narcotic effects); skin absorption (headache, coma, dermatitis); ingestion (liver and kidney damage)

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** eye-human 75 ppm; inhalation-human TCl<sub>o</sub> 75 ppm; toxic effect: nose, eye, pulmonary effects

**ACUTE HEALTH RISKS:** irritation of mucous membranes; conjunctiva irritation; changes in the sense of smell; unspecified respiratory changes; headache; narcosis; coma.

**CHRONIC HEALTH RISKS:** liver damage; damage to the kidney; may alter genetic material; experimental reproductive effects have been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm (skin); OSHA PEL TWA 50ppm (200mg/m<sup>3</sup>); NIOSH REL TWA 25 ppm (100 mg/m<sup>3</sup>)(skin); IDLH 700ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear rubber over-clothing, including gloves; wear splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb as much as possible with noncombustible materials such as dry earth, sand or vermiculite; flush and dilute remaining cyclohexanone with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, or sand, and place in a sanitary landfill; can be burned under controlled conditions; spray into incinerator or burn in paper packaging; dissolve in flammable solvent and burn incinerator equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; should be kept well separated from oxidizing agents (peroxides, nitrates, etc); should not be stored near combustible materials.

**REGULATORY INFORMATION:** S10; U waste# (U057); Reportable Quantity (RQ): 5000 lbs (2270 kg); Sfl; 120-a; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the preparation of cyclohexanone resins; used as a solvent for cellulose acetate, nitrocellulose, natural resins, vinyl resins, crude rubber, waxes, fats, shellac, and dichlorodiphenyltrichloroethane (DDT); used in organic synthesis, particularly in the production of adipic acid for nylon; used in wood stains, paint and varnish removers, spot removers, metal degreasers, polishes, and as an additive for lubricating oils.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 16.

## **CYCLOHEXENE (C<sub>6</sub>H<sub>10</sub>, 82.15)**

**CAS/DOT IDENTIFICATION #:** 110-83-8/UN2256

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**SYNONYMS:** benzene tetrahydride, tetrahydrobenzene, 1,2,3,4-tetrahydrobenzene.

**PHYSICAL PROPERTIES :** colorless liquid; sweet odor; soluble in alcohol; insoluble in water; MP (-103.5°C, -154°F); BP (83°C, 181°F); DN (0.811 g/mL at 20°C); LSG (0.81); ST (26.17 mN/m at 298.15K); VS (0.625 mPa-s at 298.15K); CP (148.3 J/K-mol liquid at 298.15K); HV (33.47 kJ/mol at 298.15K); VD (2.8); VP (160 mmHg at 38°C); OT (NA).

**CHEMICAL PROPERTIES:** flammable liquid; can react with oxidizers; FP (-11.6°C, 11°F); LFL/UFL (1.2%, NA); AT 310°C, 590°F); HC (-3.5320 x 10<sup>9</sup> J/kmol); HF (-38.5 kJ/mol liquid at 298.15K); H<sub>f</sub> (3.29 kJ/mol at 169.6K).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; very dangerous fire hazard when exposed to flame; incompatible with strong oxidizers; form explosive peroxides with oxygen upon storage; heating to decomposition emits acrid smoke and irritating fumes; use foam, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (difficulty breathing, dizziness, loss of consciousness, irritates eyes, nose, and throat); ingestion (nausea, vomiting); contact (irritates skin and eyes, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; drowsiness; narcosis; coma.

**CHRONIC HEALTH RISKS:** no known chronic health risks in humans; may possibly cause dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 300 ppm; OSHA PEL TWA 300 ppm (1015mg/m<sup>3</sup>); NIOSH REL TWA 300ppm (1015 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and self-contained breathing apparatus; hand and arm protection should be worn; chemical safety goggles are recommended where there is a danger of splashes or prolonged skin contact.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; absorb as much as possible with materials such as dry earth or sand; flush remaining cyclohexane with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; atomize large amounts in a suitable combustion chamber; dissolve in additional flammable solvent and burn in incinerator under controlled conditions; store in a cool, dry location with adequate ventilation; outside storage preferred; inside should be in a standard flammable liquids storage room or cabinet.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of adipic acid, maleic acid, hexahydrobenzoic acid and aldehyde; used in the preparation of butadiene in the laboratory; has been sug-

gested as a stabilizer for high octane gasoline; applications in organic synthesis, oil extraction, and as a solvent for catalysts.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### **CYCLOPENTADIENE (C<sub>5</sub>H<sub>6</sub>, 66.11)**

**CAS/DOT IDENTIFICATION #:** 542-92-7/UN1993

**SYNONYMS:** 1,3-cyclopentadiene, pentole, pyropentylene.

**PHYSICAL PROPERTIES :** colorless liquid; irritating, terpene-like odor; miscible with ethanol, ether, benzene, and carbon tetrachloride; soluble in carbon disulfide, acetic acid, aniline, and liquid petrolatum; insoluble in water; vapor is heavier than air; MP (-85°C, -121°F); BP (41.5-42.0°C, 106.7-107.6°F); DN (0.80475 g/mL at 19°C); LSG (0.80); VD (2.3); VP (400 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; polymerizes to dicyclopentadiene upon standing; presence of peroxides or trichloroacetic acid will accelerate polymerization; the dimer is easily depolymerized by distilling at atmospheric pressure; reacts vigorously with strong oxidizers; FP (25°C, 77°F); LFL/UFL (NA); AT (640°C, 1184°F); HF (105.9 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating (NA); dangerous fire hazard; moderate explosion hazard in form of gas; vapor/air mixtures will explode above 25°C; will readily polymerize to dimer with fire or explosion hazard; dimerization is highly exothermic; reacts violently with potassium hydroxide; reacts explosively with strong acids such as fuming nitric acid and sulfuric acid; violent reaction with dinitrogen tetroxide; forms an explosive product on reaction with nitrogen oxide and oxygen; reacts with oxygen to form a flame-sensitive explosive product; ignites on contact with oxygen and ozone; can readily form explosive peroxides on contact with air; decomposes violently at high temperatures and pressures; incompatible with oxides of nitrogen and sulfuric acid; use powder, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and nose, coughing, sore throat); eye contact (redness, pain).

**FIRST AID:** rinse eyes with plenty of water for several minutes; rinse and then wash affected areas of skin with soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if swallowed, rinse mouth and get medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and respiratory tract; cough; sore throat; reddening of eye with pain.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 75 ppm (203 mg/m<sup>3</sup>); OSHA PEL TWA 75 ppm (200 mg/m<sup>3</sup>); NIOSH REL TWA 75 ppm (200mg/m<sup>3</sup>); IDLH 750 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles where splashing is possible; above 25°C, use a closed system of local exhaust ventilation, and explosion proof electrical

equipment; wear self-contained breathing apparatus to protect against hazardous by-products of combustion, oxygen deficiency, and toxic fumes; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** collect leaking and spilled liquid in sealable containers as far as possible; absorb remaining liquid with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; use water spray to reduce vapors and to flush spills away from exposures; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a sanitary landfill; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; store only if stabilized; keep away from any area where the fire hazard may be acute; separate from incompatibles, including strong oxidants, strong acids, and potassium hydroxide; use non-sparking type tools and equipment, including explosion proof ventilation.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used in organic synthesis as the diene in the Diels-Alder reaction producing synthetic alkaloids and camphors; useful as the starting materials for synthetic prostaglandin, chlorinated insecticides, and formation of cyclopentadienyl iron dicarbonyl dimer; also used in manufacture of resins.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### 2,4-D (C<sub>8</sub>H<sub>6</sub>Cl<sub>2</sub>O<sub>3</sub>, 221.04)

**CAS/DOT IDENTIFICATION #:** 94-75-7/UN2765

**SYNONYMS:** dichlorophenoxyacetic acid, 2,4-dichlorophenoxyacetic acid, herbidal, lawn-keep, weed tox, weatrol.

**PHYSICAL PROPERTIES :** white to yellow crystalline powder; slight phenolic odor; odorless when pure; almost insoluble in water; soluble in alcohols and most organic solvents; negligible solubility in oils (e.g., petroleum oils, diesel oil, kerosene); MP (138°C, 280°F); BP (160°C, 320°F at 0.4 mmHg); DN (1.416 g/cm<sup>3</sup> at 25°C); SG (1.57 at 20°C); ST (66.5 dynes/cm at 25°C); VD (7.63); VP (53 Pa, 0.4 mmHg at 160°C); OT (3.13 mg/kg).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; substance is a weak acid; free acid is corrosive to metals; can react with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HC (-7,700 Btu/lb, -4,300 cal/g, -180 x 10<sup>3</sup> J/kg).

**EXPLOSION and FIRE CONCERNS:** not combustible; liquid formulations containing organic solvents may be flammable; reacts with strong oxidants causing fire and explosion hazard; capable of creating a dust explosion; decomposes on heating producing poisonous gases and vapors, such as hydrogen chloride and phosgene; use water, dry chemical, alcohol-resistant foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, nausea, weakness, irritates skin, eyes and respiratory tract); contact (irritates skin and eyes, burning sensation); ingestion (change in heart rate, coma, convulsions, nausea, vomiting, diarrhea, gastroenteric distress, somnolence, respiratory depression, injury to the liver and kidney, dysphagia).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, rinse mouth and drink a slurry of activated charcoal in water.

**HUMAN TOXICITY DATA:** oral-human LDLo 80mg/kg; toxic effect: gastrointestinal tract, central nervous system; oral-man LDLo 93mg/kg; toxic effect: central nervous system; oral-man TDLo 5714 mg/kg; toxic effects: behavioral effects, cardiovascular system; oral-man TDLo 2 g/kg; toxic effect: behavioral effects, pulmonary system; sister chromatid exchange-human lymphocyte 10mg/L.

**ACUTE HEALTH RISKS:** headache; nausea; vomiting; diarrhea; abdominal pain; mild central nervous system depression; dysphagia; ventricular fibrillation; transient liver and kidney injury; irritation of eyes, skin and respiratory tract; weakness; loss of consciousness.

**CHRONIC HEALTH RISKS:** kidney and liver damage; muscular weakness; stiffness of extremities; ataxia; paralysis; somnolence; convulsions; coma; possibly causes toxic effects upon human reproduction.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 10 mg/m<sup>3</sup>; NIOSH REL TWA 10 mg/m<sup>3</sup>; IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use dust and splash proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; wear positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; for extra personal protection, a P2 filter respirator for harmful particles should be worn; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; moisten first to prevent dusting; carefully collect remainder, then remove to a safe place.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry location; maintain adequate ventilation; separate from strong oxidants, food and feedstuffs.

**REGULATORY INFORMATION:** S1; S24; S32; S50; S61; S62; F2; F4; F7; F8; R3; R4; R5; D waste # (D016); Reportable Quantity (RQ): 100 lbs. (45.4kg); Sf1; Sf3; T799-5055; A1; CAL.

**OTHER COMMENTS:** used as a selective weed killer and defoliant; used for herbicide control; useful in forest management (e.g., bush control, tree injection, increases latex output of old rubber trees); basic material from which the soluble esters and salts are produced.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 13; 14; 19.

## **DECABORANE (B<sub>10</sub>H<sub>14</sub>, 122.24)**

**CAS/DOT IDENTIFICATION #:** 17702-41-9/UN1868

**SYNONYMS:** decaborane (14), decaboron tetradecahydride

**PHYSICAL PROPERTIES :** colorless to white crystalline solid; bitter, chocolate-like odor; soluble in ethyl acetate, ethyl silicate, ethyl borate, 1-bromopropane, carbon disulfide,

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carbon tetrachloride, acetic anhydride, acetic acid, benzene, and alcohol; slightly soluble in cold water; also soluble in hexane, toluene and chloroform; MP (100°C, 211°F); BP (213°C, 415°F); DN (0.94 g/cm<sup>3</sup> solid at 25°C, 0.78g/mL liquid at 100°C); SG (0.94); HV (11.6 kcal/mole); VD (NA); VP (<1mmHg at 25°C, 19mmHg at 100°C); HS (18.33 kcal/mol); OT (0.35).

**CHEMICAL PROPERTIES:** stable indefinitely at room temperature; highly reactive; reacts with amides, acetone, acetonitrile and butyraldehyde at room temperature; hydrolyzes in hot water; decomposes slowly into boron and hydrogen at 300°C; will attack some forms of plastics, rubber, and coatings; FP (80°C, 176°F); LFL/UFL (NA); AT (149°C, 300°F); HC (-28,699 Btu/lb, -15,944 cal/g, -667.10 x 10<sup>5</sup> J/kg); H<sub>f</sub> (7.8 kcal/mole).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 3, Flammability 2, Reactivity 1; mixtures with carbon tetrachloride are dangerously shock sensitive; impact-sensitive explosive mixtures are formed with ethers (e.g., dioxane) and halocarbons (e.g., carbon tetrachloride); may ignite spontaneously on exposure to air; ignites in oxygen at 100°C; incompatible with dimethyl sulfoxide, oxidizers, water, and halogenated compounds; heating to decomposition emits toxic fumes of boron oxides; use water, dry chemicals, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (headache, nausea, lightheadedness, drowsiness, nervousness); ingestion (lack of coordination, tremors, muscle spasms, generalized convulsions).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink plenty of water or milk, and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; dizziness; lightheadedness; drowsiness; headache; nausea; incoordination; tremors; muscle spasms; convulsions; vomiting; difficult breathing.

**CHRONIC HEALTH RISKS:** weakness, fatigue; liver damage; damage to the kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05 ppm; ACGIH TLV STEL 0.15 ppm (skin); OSHA PEL TWA 0.05ppm (0.3mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.05 ppm (0.3 mg/m<sup>3</sup>); NIOSH REL STEL 0.15 ppm (0.9 mg/m<sup>3</sup>); IDLH 15mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear clothing made of material resistant to decaborane; rubber boots or overshoes should be worn; rubber gloves and chemical safety goggles are recommended; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper or other suitable material, and cautiously burn in a fume hood; large quantities may be dissolved in flammable solvent, such as alcohol, and atomized in a suitable combustion chamber; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; dissolve in flammable solvent, such as alcohol, and atomize in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from oxidizing materials, halocarbons, and water.

**REGULATORY INFORMATION:** Sf2; A1; CAL; DOT hazard class/division (4.1); labels (flammable solid, poison).

**OTHER COMMENTS:** used as a catalyst in alkene polymerization; has also been used in the vulcanization of rubber; used chiefly as high energy fuels; used as a corrosion inhibitor, fuel additive, stabilizer, moth-proofing agent, dry-stripping agent, reducing agent, fluxing agent, oxygen scavenger, and rocket propellant.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 11; 12; 14.

### **DEMETON ((C<sub>2</sub>H<sub>5</sub>O)<sub>2</sub> PSOC<sub>2</sub>H<sub>4</sub>SC<sub>2</sub>H<sub>5</sub>, 258.3)**

**CAS/DOT IDENTIFICATION #:** 8065-48-3/UN 3018

**SYNONYMS:** bayer<sup>®</sup>8169, diethoxy thiaphosphoric acid ester of 2-ethylmercaptoethanol, 0,0-diethyl O (and S)-2-(ethylthio) ethyl phosphorothioate mixture, systox<sup>®</sup>.

**PHYSICAL PROPERTIES :** oily, amber-colored liquid; sulfur-like odor; soluble in most organic solvents, including ethanol, propylene glycol, toluene and similar hydrocarbons; practically insoluble in water; sinks in water; MP(<-25°C, < -13°F); BP(>140°C, >284°F at 1 atm); DN(1.1 g/mL liquid at 20°C); LSG (1.12); ST (data not available); VD (data not pertinent); VP(3 x 10<sup>-4</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; may attack some forms of plastic; can react vigorously with strong oxidizers and alkalies; FP (45°C, 113°F); LFL/UFL (1.0%, 5.3%); AT (464°C, 867°F); HC (data not available); H<sub>f</sub> (data not available).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating (no information found); compound may volatilize and form toxic fumes; vapor may explode if ignited in an enclosed area; flashback along vapor trail may occur; burning rate is 5.8 mm/min; reacts violently with strong oxidizers, such as chlorine, bromine and fluorine; poisonous gases are produced in fire, including sulfur oxides and oxides of phosphorous, use dry chemical, carbon dioxide, water spray, or foam extinguishers for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, vertigo, blurred vision, lacrimation, salivation, muscular weakness, ataxia, sweating, shortness of breath, pulmonary edema, abdominal cramps, vomiting, coma, death); skin absorption (weakness, apathy, depression, monotonous speech, sweating, twitching of the face and muscles of extremities, shallow respiration, irregular heartbeat); ingestion (nausea, vomiting, muscle twitching, abdominal soreness, diarrhea).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; begin respiratory support if breathing has stopped; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** oral-man TDLo 144 mg/kg/24D intermittent; toxic effect: true cholinesterase; oral-human LDLo 171 µg/kg; sister chromatid exchange-lymphocyte 10 mg/L.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, aching eyes; rhinorrhea (discharge of thin nasal mucus); headache; chest tightness; wheezing; laryngeal spasms; salivation; anorexia; cyanosis; sweating; abdominal cramps; nausea; vomiting; diarrhea; muscle twitching; weakness;

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paralysis; confusion; ataxia; giddiness; low blood pressure; cardiac irregularities; convulsions; coma; miosis; fatal skin absorption can occur without a feeling of skin irritation.

**CHRONIC HEALTH RISKS:** may cause mutations (genetic changes) in living cells; may damage developing fetus; may cause personality changes or depression, anxiety, or irritability; changes in red blood count or white blood count may occur.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.01 ppm (0.11/m<sup>3</sup>); OSHA PEL TWA 0.1 mg/m<sup>3</sup> (skin), NIOSH REL TWA 0.1 mg/m<sup>3</sup> (skin); IDLH 10 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear special protective clothing, including rubber boots, rubber or latex gloves, lab coat, apron or coveralls; use splash-proof safety goggles; enclose operations and use local exhaust ventilation at the site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; absorb liquid spills with noncombustible materials (e.g., dry earth, sand, vermiculite), and deposit in chemical waste containers; restrict persons not wearing protective equipment from area of spill or leak; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be necessary to contain and dispose of as a hazardous waste; dispose of in accordance with federal, state, and local regulations; store in tightly closed containers in a cool, well-ventilated area; must be stored to avoid contact with strong oxidizers (such as chlorine, bromine and fluorine).

**REGULATORY INFORMATION:** F1; F5; Sf2; A1; CAL; DOT hazard class/division (data not available).

**OTHER COMMENTS:** used as a systematic insecticide and acaricide for vegetables, orchard crops, field crops, and ornamentals.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 15; 18.

### DIACETONE ALCOHOL (C<sub>6</sub>H<sub>12</sub>O<sub>2</sub>, 116.16)

**CAS/DOT IDENTIFICATION #:** 123-42-2/UN1148

**SYNONYMS:** diacetone, 4-hydroxy-2-keto-4-methylpentane, 2-methyl-2-pentanol-4-one, pyranton, 4-hydroxy-4-methyl-2-pentanone.

**PHYSICAL PROPERTIES:** clear, colorless liquid; faint, minty odor; oily; miscible with water, alcohols, and esters, miscible with other solvents, such as aromatic and halogenated hydrocarbons; a constant-boiling mixture with water, containing approximately 13% diacetone alcohol, has boiling point (99.6°C, 211.3°F); MP (-44°C, -47°F); BP (167.9°C, 334°F at 760 mmHg); DN (0.9306 g/mL at 25°C); LSG (0.931 at 25°C); VS (0.032 poise at 20°C); VD (4.00); VP (0.97 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; may form acetone and mesityl oxide by reaction with acids or bases or upon heating; can react with oxidizing materials; prolonged exposure to alkalis and distilling at atmospheric pressure will decrease its miscibility; FP (8°C, 46°F (commercial grades); 57.8°C, 136°F (acetone free)); LFL/UFL (1.8%, 6.9%); AT (602.8°C, 117°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; NFPA rating Health 1, Flammability 3, Reactivity 0; above flash point, forms explosive vapor/air mixtures; sealed containers may rupture when heated; sensitive to static discharge; contact with strong oxidizers may cause fire; flashback along vapor trail may occur; incompatible with oxidizing agents, reducing agents, amines, alkalies, aluminum, pyridines, ammonia, isocyanates, inorganic acids and bases; carbon dioxide and carbon monoxide may form when heated to decomposition; use carbon dioxide, dry chemical or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, coughing, shortness of breath, headache, nausea, vomiting, narcosis, pulmonary changes); skin contact (irritates skin, dermatitis); eye contact (severely irritates eyes, corneal tissue damage); ingestion (irritates gastrointestinal tract, nausea, vomiting, diarrhea, symptoms parallel those from inhalation).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; immediately wash affected areas of skin with plenty of soap or water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, give large quantities of water to drink; seek medical attention immediately.

**HUMAN TOXICITY DATA:** inhalation - human TCLo 100 ppm; toxic effect: eye, central nervous system, gastrointestinal tract; inhalation - human TCLo 400 ppm; toxic effect: pulmonary effects; eye - human 100 ppm/15M.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; irritation to respiratory tract; coughing; shortness of breath; headache; nausea; vomiting; diarrhea; may affect the central nervous system; narcotic effects in high concentrations; may cause dermatitis; possible corneal burns; eye damage; pulmonary changes.

**CHRONIC HEALTH RISKS:** chronic exposure may affect liver and kidneys; can cause anemia; prolonged skin exposure may cause dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; OSHA PEL TWA 50 ppm (240 mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (240 mg/m<sup>3</sup>); IDLH 1800 ppm (based on 10% of lower explosive limit in air).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; butyl rubber or neoprene rubber are recommended protective clothing barriers; use splash proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use non-sparking tools and equipment; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use positive pressure self-contained breathing apparatus where the exposure levels are unknown or in IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; use water spray to disperse vapors and to flush spills away from exposures; collect liquid in appropriate container or absorb with non-combustible materials (e.g., dry earth, sand and vermiculite), and place in a chemical waste container; flush remaining material with large amounts of water but not into spaces such as sewers due to possibility of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb with sand or inert absorbent, and place in a secured, sanitary landfill; large amounts may be dissolved in a more flammable solvent, and sent to a RCRA approved incinerator; store in a cool, dry location; maintain adequate ventilation; outside storage is preferred; inside storage should be in a standard flammable liquids storage room or cabinet; containers should be bonded and grounded for transfers to avoid static sparks; storage containers may not be made from brass, bronze or lead, as these materials may

contaminate the product; separate from incompatibles; keep away from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose, cellulose acetate, celluloid, various oils, fats, resins, waxes, dyes, tars, lacquers, and coating compositions; used as a preservative in pharmaceutical preparations; utilized in some antifreeze solutions, in hydraulic compression fluids, and in metal-cleaning compounds; useful as a stripping agent and as a laboratory reagent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### **DIAZOMETHANE (CH<sub>2</sub>N<sub>2</sub>, 42.05)**

**CAS/DOT IDENTIFICATION #:** 334-88-3/not available

**SYNONYMS:** azimethylene, azomethylene, diazirine.

**PHYSICAL PROPERTIES:** yellow gas; musty odor; soluble in ether and dioxane; MP (-145°C, -229°F); BP (-23°C, -9.4°F); DN (1.45 g/cm<sup>3</sup> at 20°C); CP (52.5 J/mol-K); VP (>1 atm at 68°F).

**CHEMICAL PROPERTIES:** forms yellow solutions in ethereal solvents; reacts vigorously with alkali metals, water, and drying agents such as calcium arsenate.

**EXPLOSION and FIRE CONCERNS:** flammable gas; highly explosive when shocked, exposed to heat, or by chemical reactions; may explode on contact with alkali metals, rough edges such as ground glass, and on heating to 100°C; undiluted liquid and concentrated solution may explode violently, especially if impurities are present; contact with copper powder causes rapid decomposition with the formation of nitrogen and insoluble white flakes of polymethylene; decomposes rapidly in the presence of alcohols and water; incompatible with alkali metals and calcium sulfate; decomposition or contact with acid emits highly toxic fumes of NO<sub>x</sub>; use dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (eye irritation, coughing, wheezing, asthma-like symptoms); skin absorption (headache, dizziness, and nausea).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** no information available on toxicity data regarding humans.

**ACUTE HEALTH RISKS:** irritation of eyes and respiratory system; coughing; shortness of breath; wheezing; asthmatic symptoms; pulmonary edema; pneumonitis; flushing of skin; headache; dizziness; weakness; fatigue; fever; chest pains; moderate cyanosis; tremors; hypersensitivity; shock; death.

**CHRONIC HEALTH RISKS:** no information on the chronic effects in humans; IRAC Group 3: not classifiable as to its carcinogenicity to humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2ppm; OSHA PEL TWA 0.2 ppm (0.4mg/m<sup>3</sup>); NIOSH REL TWA 0.2ppm (0.4mg/m<sup>3</sup>); IDLH 2ppm.

**PERSONAL PROTECTION:** wear a gas-tight suit; wear chemical safety goggles; wear compressed air/oxygen apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; dilute to disperse vapors; if in solution, absorb with noncombustible materials such as dry earth or sand; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** if a gas, bubble into soda ash solution; add calcium hypochlorite, water and neutralize the oxidized solution; flush remaining material with large amounts of water but not into spaces such as sewers because of danger of explosion; absorb in dry earth or sand and place in a sanitary landfill; use a safety screen and a well-ventilated hood when in use.

**REGULATORY INFORMATION:** CA2; Sf3; Reportable Quantity (RQ): 100lbs (45.4kg); A1; A5; CAL.

**OTHER COMMENTS:** used as a powerful methylating agent for acidic compounds such as carboxylic acids, phenols, and enols; used as an analytical reagent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 13; 14.

### **DIBORANE (B<sub>2</sub>H<sub>6</sub>, 27.68)**

**CAS/DOT IDENTIFICATION #:** 19287-45-7/UN1911, NA1911

**SYNONYMS:** boroethane, boron hydride, diboron hexahydride.

**PHYSICAL PROPERTIES :** colorless gas; repulsive, sickly-sweet odor; soluble in carbon disulfide; soluble in tetrahydrofuran (THF) as borane-tetrahydrofuran (BH<sub>3</sub>-THF) complex; MP (-165°C, -265°F); BP (-93°C, -135°F); DN (0.447 g/mL liquid at -112°C); LSG (0.45); CP (56.9 J/K-mol gas at 25°C); HV (14.28 kJ/mol at 180.77K); VD (0.97); VP (224 mmHg at -112°C).

**CHEMICAL PROPERTIES:** thermally unstable; water reactive; hydrolyzes in water to hydrogen and boric acid; reacts with ammonia to form diborane diammoniate; reacts slowly with bromine to form boron bromides; reacts with hydrocarbons or organoboron compounds to give alkyl- or aryl-boron compounds; reacts with metal alkyls to form metal borohydrides; reacts with strong electron pair donors to form borane addition compounds; FP (-90°C, -130°F); LFL/UFL (0.9%, 98%); AT (40-50°C, 104-122°F); HF (35.6 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable gas; pyrophoric; low ignition energy; NFPA rating Health 4, Flammability 4, Reactivity 3; ignites on contact with water or moist air, evolving hydrogen; may ignite spontaneously on exposure to air at about 40-50°C; ignition or detonation of diborane-air mixtures may occur at or below room temperature when contaminants are present; highly explosive when exposed to heat or flame; may accumulate in air and explode without a source of ignition; closed containers may rupture violently when heated; reacts explosively with air tetravinyllead, octanol oxime and sodium hydroxide, benzene vapor, nitric acid, chlorine, and oxygen above 165°C; violent reaction with halocarbon liquids; reacts with aluminum or lithium to form complex hydrides that may ignite spontaneously in air; decomposes at red heat to boron and hydrogen, at lower temperatures to hydrogen and other boron hydrides; other boron hydrides can react with water or steam to evolve hydrogen or can propagate a flame rapidly enough to cause an explosion; boron hydrides can react violently with powerful oxidizing agents, such as chlorine gas, etc.; use fine spray, fog or liquid nitrogen for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (pulmonary edema, drowsiness, dizziness, visual disturbances, muscle twitching, painful muscle spasms, shortness of breath); skin absorption (nausea, headache, dizziness, vertigo); skin contact (inflammation, blisters, redness, swelling, rapid release of compressed gas may cause frostbite).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; pulmonary edema; tightening of chest; shortness of breath; precordial pain; nonproductive cough; nausea; headache; lightheadedness; vertigo; chills; fever; muscle twitching; painful muscle spasms; local inflammation of skin; blisters; redness; swelling.

**CHRONIC HEALTH RISKS:** injuries to central nervous system; liver damage; damage to kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; OSHA PEL TWA 0.1ppm (0.1mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.1 ppm (0.1 mg/m<sup>3</sup>); IDLH 15ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); in high vapor concentrations, wear self-contained breathing apparatus; wear rubber over-clothing, including gloves; wear rubber boots or overshoes; chemical safety goggles are recommended.

**SPILL CLEAN-UP:** stop or control leak if possible; use water spray to cool and disperse vapors; if in liquid form, absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; isolate from air, moisture, halogens, alkali metals, aluminum and rust; outside storage is preferred; normally refrigerated; usually shipped in pressurized cylinders diluted with hydrogen, argon, nitrogen, or helium.

**REGULATORY INFORMATION:** Sf2; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas and flammable gas).

**OTHER COMMENTS:** used as a chemical intermediate in the preparation of boron hydrides; used in the conversion of alkenes to trialkyl boranes and primary alcohols; used as a catalyst for alkene polymerization; useful as a vulcanizer for rubber, as a reducing agent, and as a flame-speed accelerator; also used in rocket propellants and as a doping gas.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 14.

### 1,2-DIBROMO-3-CHLOROPROPANE (C<sub>3</sub>H<sub>5</sub>Br<sub>2</sub>Cl, 236.35)

**CAS/DOT IDENTIFICATION #:** 96-12-8/UN2872

**SYNONYMS:** 1-chloro-2,3-dibromopropane, 3-chloro-1,2-dibromopropane, DBCP, dibromochloropropane.

**PHYSICAL PROPERTIES:** dense yellow or amber liquid; pungent odor at high concentrations; miscible with oils, dichloropropane, and isopropyl alcohol; slightly solu-

ble in water; MP (6.7°C, 44.06°F); BP (195.5°C, 384°F); DN (2.05 g/cm<sup>3</sup> at 20°C); LSG (2.05); VP (0.8 mmHg at 21°C); OT (0.3mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** stable; combustible liquid; hazardous polymerization will not occur; reacts with chemically-active metals such as aluminum, magnesium, and tin alloys; corrosive to metals; FP (76.6°C, 170°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; incompatible with strong oxidizing agents, bases, aluminum, magnesium, tin, and their alloys; when heated to decomposition emits toxic hydrogen chloride, hydrogen bromide, carbon monoxide, and carbon dioxide fumes; use carbon dioxide, dry chemical, or appropriate foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (drowsiness, nausea, vomiting, labored breath).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** dni-human hla 10mmol/L; reference dose in humans has not been established.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory tract; central nervous system depression; pulmonary edema; gastrointestinal disturbances; nausea; headaches; vomiting; kidney damage; damage to the liver.

**CHRONIC HEALTH RISKS:** primarily causes male reproductive effects; may alter genetic material; decreased sperm counts in men; effects on the liver, kidneys, central nervous system, and immune system; OSHA-regulated carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA not available; OSHA PEL TWA 0.001 ppm (cancer hazard); NIOSH REL TWA 0.01ppm/30M.

**PERSONAL PROTECTION:** use chemical-resistant gloves, boots, sleeves, aprons, etc.; use chemical safety goggles or a face shield; use positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; flush remaining residue with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; cautiously ignite small amounts in open areas; atomize large amounts in a suitable combustion chamber; store in a cool, dry place away from heat and open flames; keep the storage container tightly closed.

**REGULATORY INFORMATION:** CA2; R2-28; R3; R4; R5; R7; R8; U waste #(U066); Reportable Quantity (RQ): 1lb (.454kg); Sf1; Sf3; A1; A4; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a pesticide, nematocide, and soil fumigant; used as a chemical intermediate in the production of organic chemicals; no longer made in the United States; all other uses were canceled by the EPA in 1979.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 13; 14.

**DIBUTYL PHOSPHATE (C<sub>8</sub>H<sub>19</sub>PO<sub>4</sub>, 210.2).**

**CAS/DOT IDENTIFICATION #:** 107-66-4/none

**SYNONYMS:** dibutyl acid o-phosphate, dibutyl hydrogen phosphate, dibutyl phosphoric acid, phosphoric acid dibutyl ester.

**PHYSICAL PROPERTIES:** pale-amber liquid or oil; odorless; insoluble in water; soluble in butanol and carbon tetrachloride; MP(-13°C, 8.6°F); BP(135-138°C, 275-280°F at 0.05 mmHg); DN(1.06 g/mL at 20°C); LSG (1.06); VD(7.2); REL DN vapor/air mixture (1.01 at 20°C); VP(approximately 1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; substance is a medium strong acid; reacts vigorously with strong oxidants; decomposes above 100°C (212°F); FP(118°C, 370°F); LFL/UFL (unknown); AT (420°C, 788°F); HC(unknown).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating (not rated); attacks many metals forming flammable/explosive gas; poisonous gases are produced in a fire; contact with strong oxidizers may result in fire or explosion; substance decomposes on heating or on burning producing toxic and corrosive fumes of phosphoric acid; use powder, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, headache, sore throat, irritates eyes, skin and respiratory tract); ingestion (abdominal pain, burning sensation, sore throat).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; rinse and then wash skin with plenty of soap and water; if breathing is difficult, provide oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, rinse mouth, then give plenty of water to drink; seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory tract; headache; cough; sore throat; burning sensation; abdominal pain.

**CHRONIC HEALTH RISKS:** no information found in the literature.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 8.6 mg/m<sup>3</sup>; ACGIH TLV STEL 2 ppm (17 mg/m<sup>3</sup>); OSHA PEL TWA 1 ppm (5 mg/m<sup>3</sup>); NIOSH REL TWA 1 ppm (5 mg/m<sup>3</sup>); NIOSH REL STEL 2ppm (10 mg/m<sup>3</sup>); IDLH 30 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or in IDLH conditions; for extra personal protection, use a filter respirator for organic gases and vapors; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** collect leaking liquid in sealable containers; spilled liquid should be neutralized with caution; wash away remaining material with plenty of water.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in sealable container in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; use only with adequate ventilation; separate from strong oxidants and strong bases.

**REGULATORY INFORMATION:** T30-C10, T120-d10; Al; CAL; DOT classification (none); labels (none).

**OTHER COMMENTS:** used as an organic catalyst in many chemical reactions; utilized as an antifoaming agent.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

### **DIBUTYL PHTHALATE (C<sub>6</sub>H<sub>4</sub>(COOC<sub>4</sub>H<sub>9</sub>)<sub>2</sub>, 278.38)**

**CAS/DOT IDENTIFICATION #:** 84-74-2/ none

**SYNONYMS:** benzene-o-dicarboxylic acid di-n-butylester, DBP, dibutyl-1,2-benzenedicarboxylate, di-n-butylphthalate.

**PHYSICAL PROPERTIES:** colorless to faint yellow, oily liquid; mild, aromatic odor; very soluble in alcohol, ether, acetone, and benzene; insoluble in water; MP (-35°C, -31°F); BP (340°C, 644°F); DN (1.0484 g/mL at 20°C); LSG (1.05); VS (0.203 poise at 20°C); VD (9.58); VP (0.00007 mmHg at 20°C); Tc (513.2°C, 955.8°F).

**CHEMICAL PROPERTIES:** stable; reacts with nitrates, strong oxidizers, alkalis, and acids; reacts with liquid chlorine; FP (155.6°C, 312°F); LFL/UFL (N/A, 0.5%); AT (399°C, 750°F).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating Health 0, Flammability 1, Reactivity 0; reacts vigorously with oxidizing materials; violent reaction with chlorine; incompatible with liquid chlorine, nitrates, alkalis, and acids; emits acrid smoke and fumes when heated to decomposition; use carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, mucous membranes, and upper respiratory tract); eye contact (severe, stinging pain, profuse tears); ingestion (nausea, dizziness, photophobia).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human TDLo 140mg/kg; toxic effects: central nervous system, gastrointestinal tract, kidneys.

**ACUTE HEALTH RISKS:** irritation of eyes; irritation of upper respiratory tract; stomach irritation; nausea; vomiting; kidney effects; bladder changes; distorted perceptions; hallucinations.

**CHRONIC HEALTH RISKS:** no information is available for chronic effects in humans; EPA Group D: not classifiable as to human carcinogenicity.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5mg/m<sup>3</sup>; OSHA PEL TWA 5mg/m<sup>3</sup>; NIOSH REL TWA 5mg/m<sup>3</sup>; IDLH 4000mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear chemical-resistant gloves, boots, aprons, etc.; wear chemical safety goggles; wear a NIOSH-approved vapor respirator or other appropriate self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible in dry earth or sand for disposal in a secure sanitary landfill; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** mix with flammable solvent and inject in an incinerator equipped with afterburner and scrubber; storage should be in a cool, dry location; isolate from strong oxidizers and alkalis.

**REGULATORY INFORMATION:** CA2; R4; U waste #(U069); Reportable Quantity (RQ): 10lbs (4.54 kg); Sfl; Sf3; A1; CAL.

**OTHER COMMENTS:** used as a component in elastomers, explosives, and nail polish; used in rocket propellants; makes plastics soft and flexible; used in consumer products such as raincoats, food wraps, bowls, car interiors, vinyl fabrics, and floor tiles; used as a textile lubricating agent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 13; 14.

### **o-DICHLOROBENZENE (C<sub>6</sub>H<sub>4</sub>Cl<sub>2</sub>, 147.0)**

**CAS/DOT IDENTIFICATION #:** 95-50-1/UN1591

**SYNONYMS:** 1,2-dichlorobenzene, ortho-dichlorobenzene, ortho-dichlorobenzol.

**PHYSICAL PROPERTIES :** colorless to pale-yellow liquid; pleasant, aromatic odor; miscible with alcohol, ether, and benzene; soluble in alcohol, ether, acetone, and benzene; practically insoluble in water; MP (-17°C, 1°F); BP (180°C, 357°F); DN (1.3048 g/mL at 20°C); LSG (1.30); ST (37 dynes/cm at 20°C); VS (1.324 mPa-s at 25°C); CP (162.4 J/K-mol liquid at 25°C); HV (50.21 kJ/mol at 25°C); VD (5.05); VP (1.2 mmHg at 20°C, 1.47 mmHg at 25°C); OT (50 ppm).

**CHEMICAL PROPERTIES:** combustible liquid; mixture with ethylene dichloride and propylene dichloride can dissolve the oxide coating from aluminum containing vessel; reacts vigorously with strong oxidizers, aluminum, chlorides, acids, and acid fumes; FP (66°C, 151°F); LFL/UFL (2.2%, 9.2%); AT (648°C, 1198°F); HC (-7,969 Btu/lb, -4,427 cal/g, -185 x 10<sup>5</sup> J/kg); HF (-17.5 kJ/mol liquid at 25°C); H<sub>f</sub> (12.9 kJ/mol at 256.4K).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 2, Flammability 2, Reactivity 0; flammable when exposed to heat or flame; poisonous gases are produced in fire; reacts explosively with aluminum during storage in a sealed aluminum container; fire may be smoky due to incomplete combustion; combustion by-products include hydrogen chloride, chloro-carbons, and phosgene; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, anesthetic effects, kidney and liver damage, damage to lungs, irritates skin, eyes, and mucous membranes); skin contact (skin blisters, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support; if ingested, induce vomiting and get prompt medical attention.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of skin and eyes; destructive to tissues of mucous membranes; coughing; transient anesthesia; skin blisters; central nervous system depression.

**CHRONIC HEALTH RISKS:** may alter genetic material; possible reproductive effects; questionable carcinogen; damage to lungs, liver and kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm; ACGIH TLV STEL 50 ppm; OSHA PEL CL 50 ppm (300 mg/m<sup>3</sup>); NIOSH REL CL 50 ppm (300 mg/m<sup>3</sup>); IDLH 200ppm.

**PERSONAL PROTECTION:** wear full protective clothing; chemical-resistant gloves are recommended; wear chemical safety goggles and any self-contained breathing apparatus with a full face-piece.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; flush spills away from exposures using large amounts of water; absorb bulk liquid with materials such as fly ash or cement powder.

**DISPOSAL AND STORAGE METHODS:** absorb bulk liquid in noncombustible materials such as fly ash or activated carbon and place in a sanitary landfill sealed with an impermeable flexible membrane liner; store in a cool, dry, well-ventilated area; separate from strong oxidizers, acids, chlorides, and aluminum.

**REGULATORY INFORMATION:** S32-32; S50-b9; S61-a13; S62'-13; R2-30; R3; R4; R5; R6; R9; U waste # (U070); Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf1; T766-38; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a solvent for waxes, gums, resins, oils, asphalts, tars, and rubbers; used as an insecticide for termites; a degreasing agent for metals, leather, and wool; intermediate in the manufacture of dyes; used as a heat transfer medium; used as an ingredient of metal polishes and as a component of rust-proofing mixtures; recommended for deodorizing garbage and sewage; also used in wood-preserving compounds.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14.

## **P-DICHLOROBENZENE (C<sub>6</sub>H<sub>4</sub>Cl<sub>2</sub>, 147.02)**

**CAS/DOT IDENTIFICATION #:** 106-46-7/UN1592

**SYNONYMS:** dichloride, 1,4-dichlorobenzene, p-DCB, para-dichlorobenzene.

**PHYSICAL PROPERTIES:** colorless or white crystalline solid; mothball-like odor; sweet taste; soluble in chloroform, carbon disulfide, alcohol, ether, acetone, and benzene; insoluble in water; MP (53°C, 127°F); BP (174°C, 345°F); DN (1.2475 g/mL at 20°C); SG (1.25); ST (34.66 dynes/cm at 20°C); VS (0.839 mN/m<sup>2</sup> at 55°C, 0.668 mN/m<sup>2</sup> at 79°C); HV (17,260 cal/g); VP (1.3 mmHg at 20°C, 10mmHg at 54.8°C); OT (0.18ppm).

**CHEMICAL PROPERTIES:** volatile (sublimes readily); non-staining; non-corrosive reacts with strong oxidizer (such as chlorine or permanganate); FP (65°C, 150°F); LFL/UFL (1.8%, 7.8%); AT (647°C, 1196.6°F).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 2, Flammability 2, Reactivity 0; poisonous gases produced when heated; incompatible with oxidizing agents, aluminum and its alloys; decomposition or combustion yields carbon monoxide,

carbon dioxide and hydrogen chloride gas; use dry chemical, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and throat); skin absorption (profuse rhinitis, headaches); ingestion (nausea, vomiting, decreased weight).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human TDLo 300mg/kg; toxic effects: eye, pulmonary system, gastrointestinal tract; oral-human LDLo 857mg/kg; unreported-human LDLo 357mg/kg; unreported -man LDLo 22mg/kg; eye-human 80ppm.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, mucous membranes, and upper respiratory tract; headache; nausea; vomiting; low-weight; jaundice; cirrhosis.

**CHRONIC HEALTH RISKS:** central nervous system depression; blood disorders; EPA Group B2: probably human carcinogen; target organs: liver, kidneys, and lungs.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 75ppm; ACGIH TLV STEL 110ppm; OSHA PEL TWA 75ppm (450mg/m<sup>3</sup>); OSHA PEL STEL 110ppm (675 mg/m<sup>3</sup>); NIOSH IDLH 150ppm (6000 mg/m<sup>3</sup>).

**PERSONAL PROTECTION:** wear special protective clothing, i.e., chemical-resistant gloves, boots, aprons, etc.; wear chemical safety goggles; wear self-contained breathing apparatus..

**SPILL CLEAN-UP:** for water spill, apply activated carbon and remove trapped material with suction hoses; for land spill, dig a holding area sealed with an impermeable flexible membrane liner; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** place material in a secured, sanitary land-fill; store in a cool, dry place; keep away from heat or open flame; storage should be in tightly sealed containers.

**REGULATORY INFORMATION:** S32; S50-b; S61; S62; R2-31; R3; R4; R5; R6; R8; R9; U waste # (U072); Reportable Quantity (RQ): 100lbs (45.4kg); Sf1; T766-38; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food)..

**OTHER COMMENTS:** used as a fumigant; popular for domestic use against clothes moths; used as a deodorant for garbage and restrooms; used as an insecticide for control of ants, fruitborers, and tree-boring insects.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13; 14.

### 3,3'-DICHLOROBENZIDINE (NH<sub>2</sub>CIC<sub>6</sub>H<sub>3</sub>C<sub>6</sub>H<sub>3</sub>CINH<sub>2</sub>, 253.1)

**CAS/DOT IDENTIFICATION #:** 91-94-1/ none

**SYNONYMS:** 4,4'-diamino-3,3'-dichlorobiphenyl,O,O'-dichlorobenzidine, 3,3'-dichlorophenyl-4,4'-diamine, 3,3'-dichloro-4,4'-biphenyldiamine, 3,3'-dichloro-4,4'-diaminobiphenyl.

**PHYSICAL PROPERTIES** : gray to purple crystalline solid; readily soluble in diethyl ether, ethanol, benzene, and glacial acetic acid; insoluble in water; MP (132-133°C, 269.6-271.4°F); BP (420°C, 788°F); VP ( $1.15 \times 10^{-7}$  mmHg at 25°C).

**CHEMICAL PROPERTIES**: nonflammable; forms diazonium salts and alkyl derivatives; decomposes on heating.

**EXPLOSION and FIRE CONCERNS**: decomposition on heating; when heated to decomposition emits toxic fumes of Cl<sup>-</sup> and NO<sub>x</sub>.

**HEALTH SYMPTOMS**: inhalation (headache, dizziness, upper respiratory infection); contact (dermatitis, caustic burns); ingestion (breathing difficult, unconsciousness, blue color).

**FIRST AID**: wash eyes immediately with large amounts of water; flush affected areas of skin immediately with large amounts of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA**: dns-human hla 100nmol/L; EPA Cancer Risk Level (1 in a million excess lifetime risk):  $8.0 \times 10^{-5}$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS**: headache; dizziness; labored breath; frequent urination; caustic burns; blood in the urine; unconsciousness; upper respiratory tract infections.

**CHRONIC HEALTH RISKS**: gastrointestinal upsets; dermatitis; liver injury; EPA Group B2: probable human carcinogen.

**EXPOSURE GUIDELINES**: ACGIH TLV suspected human carcinogen; OSHA PEL cancer suspect agent; NIOSH REL reduce to lowest feasible level.

**PERSONAL PROTECTION**: wear special protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP**: sweep spilled substance into sealable containers; moisten first to prevent dusting; collect remaining material, then remove to a safe place; this chemical may not enter the environment.

**DISPOSAL AND STORAGE METHODS**: may be disposed of in sealed containers in a secured, sanitary landfill; store in well closed containers; separate from food and feedstuffs.

**REGULATORY INFORMATION**: CA2; R3; R4; R5; U waste # (U073); Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sf1; Sf3; CW4; CW5; A1; A4.

**OTHER COMMENTS**: used in the manufacture of azo dyes, textiles, plastics, and crayons; used as an intermediate in the production of pigments; used as an intermediate in the detection of gold.

**KEY REFERENCES**: 3; 4; 5; 6; 7; 12; 13; 14.

## DICHLORODIFLUOROMETHANE (CCl<sub>2</sub>F<sub>2</sub>, 120.91)

**CAS/DOT IDENTIFICATION #**: 75-71-8/UN1028

**SYNONYMS**: difluorodichloromethane, fluorocarbon-12, freon<sup>®</sup>12, genetron<sup>®</sup>12, halon<sup>®</sup>122, propellant 12, refrigerant 12.

**PHYSICAL PROPERTIES** : colorless gas or liquefied compressed gas; ether-like odor at extremely high concentrations; otherwise, practically odorless; soluble in alcohol,

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ether, and other common organic solvents; insoluble in water; MP (-158°C, -252°F); BP (-29.8°C, -21.6°F at 760 mmHg); DN (1.486 g/mL at -29.8°C); LSG (1.49 at -29.8°C); ST (9 dynes/cm); VS (0.262 cP at 70°F); CP (72.3 J/K-mol gas at 25°C); HV (20.11 kJ/mol at 243.3K); VD (4.2); VP (84.8 psia at 70°F).

**CHEMICAL PROPERTIES:** nonflammable gas; stable up to 550°C (1022°F); non-corrosive; can react with chemically-active metals such as aluminum, sodium, potassium, calcium, zinc, and magnesium; FP (NA); LFL/UFL (NA); AT (NA); HC (nonflammable); HF (-477.4 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** not flammable; NFPA rating (NA); can react violently with aluminum; contact with a flame or hot metal surface may form toxic substances; incompatible with chemically-active metals; heating to decomposition emits toxic fumes of phosgene, chlorides, and fluorides; use flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, dizziness, tremors, fibrosing alveolitis, liver changes, narcosis, asphyxiation); contact (cardiac arrhythmias, cardiac arrest, liquid may cause frostbite).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCl<sub>o</sub> 200,000 ppm/30M; toxic effect: eye, liver pulmonary effects.

**ACUTE HEALTH RISKS:** dizziness; tremors; asphyxiation; unconsciousness; cardiac arrest; narcosis; conjunctiva irritation.

**CHRONIC HEALTH RISKS:** fibrosing alveolitis; liver changes; cardiac arrhythmias.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm; OSHA PEL TWA 1000 ppm (4950mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (4950 mg/m<sup>3</sup>); IDLH 15,000 ppm.

**PERSONAL PROTECTION:** use impervious clothing and chemical-resistant gloves; use splash-proof safety goggles and positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak to disperse gas; stop flow of gas if possible; if in liquid form, absorb as much as possible with noncombustible materials such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** ventilate area of spill or leak and release to air; absorb in dry earth, sand or vermiculite and dispose of in a secured, sanitary landfill; store in a cool, dry location with adequate ventilation; keep away from chemically-active metals such as powdered aluminum, zinc and magnesium

**REGULATORY INFORMATION:** S3; S40-j13; R3; R4; R5; R6; R8; U waste # (U075); Reportable Quantity (RQ): 5000 lbs (2270 kg); Sf1; Sf3; A1; CAL; DOT hazard class/division (2.2); labels (nonflammable gas).

**OTHER COMMENTS:** used in the manufacture of and extensive use as a refrigerant in home and commercial applications; used as refrigerants in home appliances, air conditioning units, and retail food refrigeration systems; used in regulating devices for leak detection, in thermal expansion valves, and in insulators for electrical applications; useful as foaming agent in fire extinguishing aerosols; also used in water, copper and aluminum purification, petroleum recovery and in manufacture of glass bottles.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 11; 12; 14.

### **1,3-DICHLORO-5,5-DIMETHYL HYDANTOIN (C<sub>5</sub>H<sub>6</sub>Cl<sub>2</sub>N<sub>2</sub>O<sub>2</sub>, 197.03)**

**CAS/DOT IDENTIFICATION #:** 118-52-5/none

**SYNONYMS:** dactin, ddh, dichlorodimethylhydantoin, 1,3-dichloro-5,5-dimethyl-2,4-imidazolidinedione, halane.

**PHYSICAL PROPERTIES:** white solid, characterized by four sided, pointed prisms; mild, chlorine-like odor; turns brown at 212°C (413.6°F), after melting at 132°C (269.6°F); slightly soluble in water; freely soluble in chlorinated and highly polar solvents at 25°C, including benzene, chloroform, ethylene dichloride, carbon tetrachloride, methylene chloride, sym-tetrachlorethane, and alcohol; MP (132°C, 270°F); BP (unknown); DN (1.5 g/cm<sup>3</sup> at 20°C); SG (1.5); VD (6.8); VP (unknown).

**CHEMICAL PROPERTIES:** contains approximately 36% active chlorine; dry crystals, containing 77.6% available chlorine, may be stored without losing much available chlorine; will suffer a loss of 1.5% chlorine after 14 weeks at 60°C (140°F); liberates hypochlorous acid on contact with water, and, in particular, hot water; sublimes approximately at 100°C (212°F); forms nitrogen chloride at pH 9; FP (174.4°C, 346°F); LFL/UFL (unknown); AT (unknown); HC (information not found in the literature).

**EXPLOSION and FIRE CONCERNS:** combustible with evolution of chlorine at 210°C (410°F); NFPA rating (not rated); may form explosive mixtures with xylene; reaction with water or steam will produce poisonous and corrosive fumes; incompatible with strong acids; contact with easily oxidized materials (such as ammonia salts and sulfides), will result in fire and explosion; heating to decomposition emits toxic fumes of chlorine and oxides of nitrogen; use dry chemical, foam, carbon dioxide, or other extinguishing agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, throat, and skin); contact (severely irritates skin, allergic dermatitis); ingestion (central nervous system depressant, severely irritates respiratory system, may cause impairment of lungs)

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; flush affected areas of skin with large amounts of soap and water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, give plenty of water to drink; seek medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** severe irritation of eyes and skin; severe respiratory irritation; corrosive to the mucous membranes and lungs; irritating to the nose and throat; allergic reaction may occur; depression of central nervous system.

**CHRONIC HEALTH RISKS:** corrosive, with possible permanent eye damage corrosive, with possible permanent skin damage; allergic dermatitis; mutation data has been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg/m<sup>3</sup>; ACGIH TLV STEL 0.4 mg/m<sup>3</sup>; OSHA PEL TWA 0.2 mg/m<sup>3</sup>; NIOSH REL TWA 0.2 mg/m<sup>3</sup>; NIOSH REL STEL 0.4 mg/m<sup>3</sup>; IDLH 5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron, or slicker suit; wear chemical goggles or face shield;

enclose operations and/or use local exhaust ventilation at the site of release; wear a disposable dust mask, as well as a cartridge respirator with pre-filter and/or high efficiency cartridge if significant dusting occurs; for enclosed spaces with inadequate ventilation, positive pressure self-contained breathing apparatus is recommended; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** sweep and/or vacuum up solid and reclaim into recovery/salvage drums for disposal; if appropriate, moisten spill first, in order to prevent dispersion of dust; flush spill area with large amounts of water, but not into lakes, ponds, streams, waterways, and public water supplies; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** as hazardous solid waste, this chemical must be disposed of in a licensed hazardous waste treatment facility, in accordance with federal, state, and local regulations; store in a cool, dry location; use with adequate ventilation; isolate container in open air; separate from strong oxidizing agents and organic materials; avoid high temperatures, direct sunlight, and contamination with moisture.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none); label (none).

**OTHER COMMENTS:** used as mild chlorinating agent, as a disinfectant in water treatment, and as an industrial deodorant; an active ingredient of household laundry bleach; utilized as a chemical intermediate for amino acids, pharmaceuticals, and insecticides; use as a stabilizing agent for vinyl chloride polymers; applications as a catalyst in polymerization reactions.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 18.

### **DICHLORODIPHENYL TRICHLOROETHANE (C<sub>14</sub>H<sub>9</sub>Cl<sub>5</sub>, 354.48)**

**CAS/DOT IDENTIFICATION #:** 50-29-3/UN2761

**SYNONYMS:** agritan, azotox, 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane, chlorophenothane, ddt, dicophane, diphenyltrichloroethane, gesapon, gesarol, ixodex, 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane.

**PHYSICAL PROPERTIES :** colorless crystals or white to off-white powder; odorless or slight, aromatic odor; insoluble in water; practically insoluble in dilute acids and alkalis; soluble in acetone, benzene, ether, carbon tetrachloride, kerosene, morpholine, tetralin, and tributyl phosphate; freely soluble in pyridine and dioxane; solubility in organic solvents increases with elevated temperatures; MP (108.5-109°C, 227-228°F); BP (260°C, 500°F); DN (1.5 g/cm<sup>3</sup>); SG (0.99 at 20°C); VP (1.5 x 10<sup>-7</sup> mmHg at 20°C); UV MAX (236nm).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; difficulties in residue removal from water, soil and foodstuffs due to unusual stability; resistant to destruction by light and oxidation; reacts with organic and inorganic bases, aluminum, and iron; FP (72-77°C, 162-171°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible solid; liquid formulations containing organic solvents may be flammable; risk of fire and explosion if formulations contain flammable or explosive solvents; incompatible with alkaline materials and strong oxidizers; on combustion, forms toxic and corrosive fumes of hydrogen chloride; use water spray, powder, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, sore throat, irritates eyes, skin and respiratory tract); skin absorption (numbness, coarse tremors, fatigue, weakness, convulsions, respiratory failure); ingestion (anesthesia, headache, convulsions, cardiac arrhythmias, nausea, vomiting, sweating, diarrhea, hyper-excitability, paresthesias of tongue, lips and face).

**FIRST AID:** wash eyes with water for several minutes; promptly wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; in case of ingestion, rinse mouth; give a slurry of activated charcoal in water to drink and induce vomiting; get prompt medical attention.

**HUMAN TOXICITY DATA:** oral-human TDLo 16mg/kg; toxic effect: central nervous system; oral-human LDLo 500 mg/kg; toxic effect: central nervous system, cardiovascular system, pulmonary system; oral-human TDLo 5mg/kg; toxic effect: central nervous system; oral-man TDLo 6mg/kg; toxic effect: central nervous system, gastrointestinal tract, skin; unreported-man LDLo 221 mg/kg; oral-infant LDLo 150 mg/kg; cytogenetic analysis-human lymphocyte 200µg/L/72H.

**ACUTE HEALTH RISKS:** irritation to eyes, skin and respiratory tract; cough; dizziness; numbness; paresthesias; tremors; moderate ataxia; malaise; headache; sore throat; fatigue; weakness; confusion; apprehension; nausea; vomiting; diarrhea; sweating; unspecified pulmonary changes; cardiac arrhythmias; anesthetic effects; convulsions; coma; death due to respiratory failure.

**CHRONIC HEALTH RISKS:** may have effects on central nervous system; may also have effects on the liver; possible carcinogenic to humans; possible toxic effects upon human reproduction based on animal tests.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg/m<sup>3</sup>; OSHA PEL TWA 1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup> avoid skin contact; IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection if powder; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing protection apparatus; for extra personal protection, wear P3 filter respirator for toxic particles; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; sweep spilled substance into sealable non-metallic containers; moisten first to prevent dusting; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substance into sealable non-metallic containers and place in a secured, sanitary landfill; dispose of in accordance with federal, state and local regulations; store in a cool, dry, well-ventilated location; high storage temperatures should be avoided; should not be kept in iron containers and should not be mixed with iron, aluminum and its salts, and alkaline substances; separate from food and feedstuffs.

**REGULATORY INFORMATION:** R8; Reportable Quantity (RQ): 1 lb (0.454 kg); A1; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as an insecticide (for cotton and tobacco); substance may be hazardous to the environment; special attention should be given to birds and aquatic organisms.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

**1,1-DICHLOROETHANE (CHCl<sub>2</sub>CH<sub>3</sub>, 98.96)****CAS/DOT IDENTIFICATION #:** 75-34-3/UN2362**SYNONYMS:** asymmetrical dichloroethane, ethylidene chloride, 1,1-ethylidene dichloride.**PHYSICAL PROPERTIES :** colorless, oily liquid; chloroform-like odor; saccharine taste; soluble in alcohol, ether, fixed and volatile oils; very sparingly soluble in water; MP (-98°C, -144.4°F); BP (57-59°C, 134-138°F); DN (1.174 g/mL at 17°C); LSG (1.18); ST (24.07 mN/m at 298.15 K); VS (0.464 mPa-s at 298.15 K); CP (126.3 J/mol-K liquid at 298.15 K); HV (30.62 kJ/mol at 298.15K); VD (3.44); VP (230 mmHg at 25°C); OT (120 ppm).**CHEMICAL PROPERTIES:** volatile; reacts vigorously with oxidizing agents and strong caustics; prepared by the action of phosphorus pentachloride (PCl<sub>5</sub>) on acetaldehyde; FP (-5.6°C, 22°F); LFL/UFL (5.4%, 11.4°); AT (457.8°C, 856°F); HF (-158.4 kJ/mol liquid at 298.15 K).**EXPLOSION and FIRE CONCERNS:** flammable liquid; dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 0; moderate explosion hazard when exposed to heat or flame; incompatible with oxidizing materials and strong caustics; decomposition emits highly toxic fumes of phosgene and Cl; use dry chemical, carbon dioxide, foam, or water for firefighting purposes.**HEALTH SYMPTOMS:** inhalation (irritates skin, cardiac effects); contact (skin burns, scaliness, rashes).**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.**HUMAN TOXICITY DATA:** no data available regarding toxic effects in humans.**ACUTE HEALTH RISKS:** skin irritation; central nervous system depression; cardiostimulatory effects; cardiac arrhythmias.**CHRONIC HEALTH RISKS:** liver damage; kidney damage; lung damage; decreased body weight; noncancerous effects.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm; ACGIH STEL 250 ppm; OSHA PEL TWA 100 ppm (400mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (400mg/m<sup>3</sup>); IDLH 3000 ppm.**PERSONAL PROTECTION:** wear special protective clothing; wear chemical-resistant gloves; wear splash-pooof safety goggles; wear self-contained breathing apparatus; avoid prolonged or repeated exposure.**SPILL CLEAN-UP:** evacuate area; absorb as much as possible with materials such as dry earth, sand, or vermiculite; remove all ignition sources; ventilate area and wash spill site after material pickup.**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; store in a cool, dry, well-ventilated location; do not use handling equipment or containers composed of magnesium, aluminum or their alloys.

**REGULATORY INFORMATION:** S1; S3; S40-e9; 2-49; R2-33; R3; R5; R7; Reportable Quantity (RQ): 1000 lbs (454 kg); CW4; CW5; T30-e10; T799-5055; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of 1,1,1-trichloroethane and vinyl chloride; used as a solvent for extraction; used in the manufacture of high vacuum rubber and plastics.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 13; 14.

## 1,2-DICHLOROETHYLENE (C<sub>2</sub>H<sub>2</sub>Cl<sub>2</sub>, 96.94)

**CAS/DOT IDENTIFICATION #:** 540-59-0/UN1150

**SYNONYMS:** acetylene dichloride, cis-acetylene dichloride, trans-acetylene dichloride, 1,2-dichloroethene, sym-dichloroethylene.

**PHYSICAL PROPERTIES :** colorless liquid; usually a mixture of the cis and trans isomers; slightly acid, chloroform-like odor; soluble in alcohol, ether and most common organic solvents; insoluble in water; MP (-81.5 to -49.4°C, -115 to -57°F); BP (47.2-60°C, 117-140°F); DN (1.257-1.282 g/mL at 20°C); LSG (1.27 at 77°F); VS (cis isomer 0.445 mPa-s, trans isomer 0.317 mPa-s at 298.15K); CP (cis isomer 116.4 J/K-mol, trans isomer 65.1 J/K-mol liquid at 298.15K); HV (cis isomer 31.57 kJ/mol, trans isomer 30.04 kJ/mol at 298.15K); VP (180-265mmHg at 20°C).

**CHEMICAL PROPERTIES:** flammable liquid; hazardous polymerization may occur when subjected to elevated temperatures, oxidizing materials, peroxides, or sunlight; usually contains inhibitors to prevent polymerization; uninhibited monomer vapor may form polymer in confined spaces; prolonged contact with air may form organic peroxides; reacts with alkalis and alkali metals, such as aluminum; slowly decomposes on exposure to air, light and moisture, forming hydrogen chloride; FP (18-21°C, 36-39°F); LFL/UFL (5.6%, 12.8%); AT (460°C, 860°F); HF (cis isomer -26.4 kJ/mol, trans isomer -23.1 kJ/mol liquid at 298.15K).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 2, Flammability 3, Reactivity 2; flashback along vapor trail may occur; closed containers may rupture violently when heated; incompatible with strong oxidizers and alkalies, potassium hydroxide, and copper; combustion by-products may include hydrogen chloride and phosgene gas; use dry chemical, foam, carbon dioxide, or flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (central nervous system depression, narcosis, irritates eyes, skin and respiratory system).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; dizziness; headache, narcosis; difficult breathing; collapse; death from asphyxiation.

**CHRONIC HEALTH RISKS:** central nervous system depression; slight inhalation hazard with chronic intake.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm; OSHA PEL TWA 200ppm (790mg/m<sup>3</sup>)(skin); NIOSH REL TWA 200 ppm (790 mg/m<sup>3</sup>); IDLH 1000ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); in high vapor concentrations, use impervious clothing and chemical resistant gloves; use splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use appropriate foam to blanket release and suppress vapors; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; separate from air, light, heat, and strong oxidizing materials.

**REGULATORY INFORMATION:** Sf3; T30-e10; T120-d10; A1; CAL.

**OTHER COMMENTS:** used as a solvent for fats, phenol, camphor, etc.; general solvent for dye extraction, perfumes, lacquers, thermoplastics and organic synthesis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 14.

### DICHLOROETHYL ETHER (ClCH<sub>2</sub>CH<sub>2</sub>OCH<sub>2</sub>CH<sub>2</sub>Cl, 143.0)

**CAS/DOT IDENTIFICATION #:** 111-44-4/UN1916

**SYNONYMS:** bis(2-chloroethyl)ether, 2,2'-dichlorodiethyl ether, 2,2'-dichloroethyl ether.

**PHYSICAL PROPERTIES :** colorless liquid; strong, chlorinated solvent-like odor; miscible in diethyl ether, methanol, and benzene; insoluble in water; dissolves oils, fats, and greases; MP (-52°C, -62°F); BP (179°C, 352°F); DN (1.2220 g/mL at 20°C); LSG (1.22); VD (4.93); VP (0.7 mmHg at 20°C); OT (0.049 ppm).

**CHEMICAL PROPERTIES:** stable liquid; will not polymerize; reacts with strong acids and oxidizing materials; FP (55°C, 131°F); LFL/UFL (2.7%, NA); AT (369°C, 696°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid when exposed to heat, flame, or oxidants; NFPA rating Health 2, Flammability 2, Reactivity 0; dangerous explosion hazard; reacts vigorously with oleum and chlorosulfonic acid; reaction with water or steam produces toxic and corrosive fumes; formation of peroxides may occur in containers that have been opened and remain in storage; incompatible with strong oxidizers; decomposes in the presence of moisture to form hydrochloric acid; use dry chemical, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, and respiratory system); skin absorption (coughing, nausea and vomiting).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** EPA Cancer Risk Level (1 in a million excess lifetime risk)  $3 \times 10^{-6}$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of nose, throat and respiratory tract; lacrimation; coughing; nausea; vomiting; pulmonary edema; hemorrhage of the lungs; central nervous system effects; death in high concentrations.

**CHRONIC HEALTH RISKS:** liver and kidney damage; damage to the lung; EPA Group B2: probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; ACGIH TLV STEL 10 ppm (skin); OSHA PEL TWA 5 ppm; OSHA PEL STEL 10 ppm (skin); NIOSH REL TWA 5 ppm (30 mg/m<sup>3</sup>); NIOSH REL STEL 10 ppm (60mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear special protective clothing and chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; atomize in a suitable incinerator, equipped with afterburner and scrubber; store in a cool, dry, well-ventilated location; keep away from strong acids, oxidizers, heat, and sunlight.

**REGULATORY INFORMATION:** CA2; R3; R4; U waste # (U025); Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf2; A1; CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid).

**OTHER COMMENTS:** used in the manufacture of pesticides, paints and varnishes; used in the purification of oils and gasoline; used as a solvent for fats, waxes, greases, and esters.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 12; 13; 14.

## DICHLOROMONOFUOROMETHANE (CHCl<sub>2</sub>F, 102.92)

**CAS/DOT IDENTIFICATION #:** 75-43-4/UN1029

**SYNONYMS:** dichlorofluoromethane, fluorocarbon 21, fluorodichloromethane, freon<sup>®</sup> 21, genetron<sup>®</sup> 21, halon<sup>®</sup> 112, refrigerant 21.

**PHYSICAL PROPERTIES :** clear, colorless, heavy gas; compressed liquefied gas below 48°F; slight ether-like odor; soluble in alcohol and ether; insoluble in water; gas is heavier than air; MP (-135°C, -211°F); BP (8.9°C, 48°F); DN (1.426 g/mL liquid at 0°C); CP (60.9 J/K-mol gas at 25°C); HV (24.23 kJ/mol at 25°C); VD (3.82); VP (1.6 atm at 70°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; attacks some forms of plastics, rubber and coatings; reacts with chemically active metals; FP (NA); LFL/UFL (NA); AT (522°C, 972°F); P<sub>c</sub> (51.0 atm, 38,760 mmHg).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; not combustible; violent reaction with chemically active metals such as sodium, potassium, calcium, powdered aluminum, zinc, and magnesium; reacts with acids or acid fumes producing highly toxic fumes of chlorine and fluorine; decomposes on heating producing corrosive and highly toxic fumes of hydrogen chloride, hydrogen fluoride, and phosgene; all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (asphyxia, irregular heartbeat, drowsiness, effects on respiratory system); contact (liquid may cause frostbite).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; on frostbite, rinse skin with plenty of water and get medical attention; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration and refer to medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** drowsiness; loss of consciousness due to asphyxia; may cause effects on central nervous system; cardiac arrhythmia; cardiac arrest; liquid may cause frostbite.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (42 mg/m<sup>3</sup>); OSHA PEL TWA 1000 ppm (4200 mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (40 mg/m<sup>3</sup>); IDLH 5000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, cold-insulating gloves, lab coat, apron or coveralls; wear chemical safety goggles or eye protection in combination with breathing protection; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; turn leaking cylinder with the leak up to prevent escape of gas in liquid state; never direct water jet on liquid; this chemical should not be allowed to enter environment; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** do not allow this chemical to enter the environment; dispose of in accordance with federal, state and local requirements; store in a cool, dry location; maintain adequate ventilation; fireproof if in building; separate from strong acids and chemically active metals; do not store in the vicinity of any area where the fire hazard may be acute; keep away from areas where welding operations are in progress.

**REGULATORY INFORMATION:** T120-a; A1; CAL; DOT hazard class/division (2.2); labels (nonflammable gas).

**OTHER COMMENTS:** used as a solvent and as a refrigerant; this substance may be hazardous to the environment; special attention should be given to the ozone layer.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### 1,1-DICHLORO-1-NITROETHANE (CH<sub>3</sub>CCl<sub>2</sub>NO<sub>2</sub>, 143.96)

**CAS/DOT IDENTIFICATION #:** 594-72-9/UN2650

**SYNONYMS:** dichloronitroethane, dichloro-1-nitroethane, ethide.

**PHYSICAL PROPERTIES:** colorless liquid; unpleasant odor; slightly soluble in water; MP (data not available); BP (124°C, 255.2°F at 760 mmHg); DN (1.4153 g/mL at 20°C); SG (1.43 at 20°C); VD (4.97); VP (15 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; corrosive to iron in presence of moisture; can

react vigorously with oxidizing materials; FP (76°C, 168°F (open cup)); LFL/UFL (data not available); AT (data not available).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; flammable upon exposure to heat, flame, or oxidizing agents; NFPA rating Health 2, Flammability 2, Reactivity 3; contact with oxidizing materials may cause fires or violent reactions; toxic gases and vapors such as hydrogen chloride, carbon monoxide, and oxides of nitrogen may be released in a fire; for small fires, use carbon dioxide, dry chemical, water spray, or regular foam; use water spray, fog, or regular foam to fight large fires.

**HEALTH SYMPTOMS:** inhalation (Note: no signs or symptoms of acute or chronic exposure to 1,1-dichloro-1-nitroethane have been reported in humans). The following symptoms are based on analogy with effects in animals. inhalation (pulmonary edema, acute bronchitis, nasal congestion, sneezing, coughing, irritates eyes, skin, and lungs); contact (swelling and severe skin irritation, hemorrhage, congestion of blood vessels); ingestion (degeneration of the liver, may cause kidney and heart muscle damage).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; immediately wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** (Note: No effects of either acute or chronic exposure to 1,1-dichloro-1-nitroethane have been reported in humans). Based on testing in animals, exposure is expected to cause eye, skin and pulmonary irritation in humans; in animals, this chemical causes pulmonary edema and hemorrhage, congestion of blood vessels, acute bronchitis, increased tearing, nasal congestion, sneezing, coughing, weakness, as well as swelling and severe skin irritation.

**CHRONIC HEALTH RISKS:** (Note: no effects of either acute or chronic exposure to 1,1-dichloro-1-nitroethane have been reported in humans). Based on testing in animals, severe overexposure may cause liver, kidney, and heart muscle damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (12 mg/m<sup>3</sup>); OSHA PEL CL 10 ppm (60 mg/m<sup>3</sup>); OSHA PEL TWA 2 ppm (10 mg/m<sup>3</sup>); NIOSH REL TWA 2 ppm (10 mg/m<sup>3</sup>); IDLH 25 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, sleeves, or encapsulating suits or coveralls; wear splash-proof chemical safety goggles or face shields; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where the ambient concentration of this chemical exceeds the permissible exposure level; wear self-contained breathing apparatus during operations that involve unknown exposures or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** stop leak if it is possible to do so without risk; ventilate area of spill or leak; water spray may be used to reduce vapors, but may not prevent ignition in closed spaces; absorb small spills with sand or other noncombustible absorbent materials and place into chemical waste containers for later disposal; for large liquid spills, build dikes far ahead of the spill to contain materials for later disposal; remove all sources of heat or ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and dispose of in a secured, sanitary landfill; disposal should be in accordance with federal, state and local regulations; storage should be in a cool, well-ventilated area in tightly sealed containers; containers should be bonded and grounded to protect against physical damage; store separately from oxidizing materials; avoid contact with heat or flame.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (6.1); label (poison).

**OTHER COMMENTS:** used as an insecticidal fumigant for grain; use as a solvent and in organic synthesis.

**KEY REFERENCES:** 4; 5; 6; 7; 16.

### DICHLOROTETRAFLUOROETHANE (C<sub>2</sub>Cl<sub>2</sub>F<sub>4</sub>, 170.92)

**CAS/DOT IDENTIFICATION #:** 76-14-2/UN1958

**SYNONYMS:** 1,2-dichlorotetrafluoroethane, 1,2-dichloro-1,1,2,2-tetrafluoroethane, freon<sup>®</sup>114, genetron<sup>®</sup>114, halon<sup>®</sup>242, refrigerant 114.

**PHYSICAL PROPERTIES:** colorless gas; faint, ethereal odor at high concentrations; liquefied compressed gas below 38°F; soluble in alcohol and ether; practically insoluble in water; MP (-94°C, -137°F); BP (3.55°C, 38.39°F); DN (1.5312 g/mL liquid at 0°C); CP (111.7 J/K-mol liquid at 25°C); HV (23.25 kJ/mol at 276.9K); VD (5.93); VP (1.9 atm, 1444 mmHg at 70°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; non-corrosive gas; incompatible with chemically-active metals such as sodium, potassium, calcium, powdered aluminum, zinc, and magnesium; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-939.7 kJ/mol liquid at 25°C, -916.3 kJ/mol gas at 25°C); H<sub>f</sub> (6.32 kJ/mol at 179K).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; NFPA rating (not rated); some may burn, but none ignite readily; containers may explode when heated; ruptured cylinders may rocket; reacts violently with chemically active metals (such as sodium potassium, zinc, powdered aluminum, and magnesium); will form toxic substances on contact with open flame or red-hot metal surface; emits highly toxic chloride fumes on contact with acids or acid fumes; hazardous decomposition products include hydrofluoric and hydrochloric acid, along with smaller amounts of phosgene and carbonyl fluoride; use dry chemical, carbon dioxide, water spray, fog or regular foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (confusion, pulmonary irritation, tremors, laryngeal spasm or edema, coughing, shortness of breath, dizziness, lightheadedness, irritates nose and throat); contact (irritates eyes and skin, causing a rash or burning feeling); ingestion (depression of central nervous system, dizziness, lightheadedness, liver damage, other symptoms parallel those of inhalation).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with large amounts of soap and water; administer oxygen if breathing is difficult; begin rescue breathing if breathing has stopped; in case of ingestion, transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to respiratory system; irritation to nose and throat; pulmonary edema; coughing; dyspnea (breathing difficulty); dizziness; lightheadedness; pulmonary irritation; tremors; oxygen displacement; cardiac arrhythmias; cardiac arrest; liquid may cause frostbite; death due to asphyxiation.

**CHRONIC HEALTH RISKS:** repeated exposure may reduce the number of white blood cells or damage the liver; may worsen pre-existing respiratory conditions caused by chemical exposure, leading to chronic respiratory disease.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm; OSHA PEL TWA 1000 ppm (7000 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (7000 mg/m<sup>3</sup>); IDLH 15,000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles or face shields; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where the potential exists for exposures over 1000 ppm; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; stop leak without risk, if possible; water spray may be used to reduce vapors, or divert vapor cloud drift; absorb liquids in dry earth, sand or vermiculite, and deposit in chemical waste containers.

**DISPOSAL AND STORAGE METHODS:** if in liquid form, absorb in sand or inert absorbent, and dispose of in a secured, sanitary landfill; store in tightly closed containers in a cool, well-ventilated area; avoid contact with open flame or very hot surfaces; separate from incompatibles such as acids and chemically-active metals.

**REGULATORY INFORMATION:** Sf3; A1; DOT hazard class/division (none); label (none required).

**OTHER COMMENTS:** used as a solvent, refrigerant and air conditioner fluid, blowing agent, dielectric fluid, and as a component of fire extinguishers.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8.

**DICHLORVOS((CH<sub>3</sub>O)<sub>2</sub>P(O)OCH=CCl<sub>2</sub>, 220.98)**

**CAS/DOT IDENTIFICATION #:** 62-73-7/UN2783

**SYNONYMS:** DDVP, 2,2-dichloroethanol dimethyl phosphate, 2,2-dichlorovinyl dimethyl phosphate, 2,2-dichlorovinyl dimethyl phosphoric acid ester, phosphoric acid-2,2-dichloroethenyl dimethyl ester.

**PHYSICAL PROPERTIES :** colorless to amber liquid; mild, aromatic chemical odor; miscible with aromatic and chlorinated hydrocarbon solvents and alcohol; slightly soluble in water and glycerin; BP(140°C, 284°F at 20 mmHg); DN (1.415 g/mL at 25°C); LSG (1.42); VP (0.012 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable to heat; reacts vigorously with strong acids and strong alkalis; corrosive to iron and mild steel; FP (>79.4°C, >175°F).

**EXPLOSION and FIRE CONCERNS:** practically non-flammable; NFPA rating Health 3; Flammability 1; Reactivity NA; hydrochloric gas, phosphoric acid mist and carbon monoxide gas may be released in a fire; decomposition emits very toxic fumes of  $\text{Cl}^-$  and  $\text{PO}_x$ ; use carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin); skin absorption (respiratory failure, headache, nausea, giddiness).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** dns-human other cell types 65mmol/L; dni-human lymphocyte 62 mg/L.

**ACUTE HEALTH RISKS:** irritation of eyes, and skin; nausea; vomiting; diarrhea; sweating; low blood pressure; cardiac irregularities; muscle twitching; paralysis; giddiness; ataxia; convulsions; wheezing; chest tightening; laryngeal spasms; salivation; cyanosis; anorexia; blurred vision; lacrimation; aching eyes; rhinorrhea (discharge of thin nasal mucous); respiratory failure.

**CHRONIC HEALTH RISKS:** decreased plasma levels; reduction in cholinesterase levels in blood; EPA Group B2; probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (skin); OSHA PEL TWA 1mg/m<sup>3</sup>(skin); NIOSH REL TWA 1 mg/m<sup>3</sup>(skin); IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear special protective clothing, i.e., gas-tight suit, boots, gloves, aprons, etc.; wear chemical safety goggles; use compressed air/oxygen apparatus.

**SPILL CLEAN-UP:** absorb bulk liquids with fly ash or cement powder; dig a pit, pond, lagoon, or holding area to contain liquid; holding areas should be sealed with an impermeable flexible membrane liner.

**DISPOSAL AND STORAGE METHODS:** apply absorbent material (dry earth, sand, straw, etc.) to contaminated area; place in plastic-lined impervious containers and incinerate in a pesticide incinerator; material may also be buried in a chemical waste landfill.

**REGULATORY INFORMATION:** CA2; Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf2; Sf3; CW1; CW2; A1; CAL;

**OTHER COMMENTS:** used as an agricultural insecticide; used as an anthelmintic (worming agents); used as a botacide (agent that kills larvae).

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13; 14.

### DICYCLOPENTADIENYL IRON ( $\text{C}_{10}\text{H}_{10}\text{Fe}$ , 186.05)

**CAS/DOT IDENTIFICATION #:** 102-54-5/none

**SYNONYMS:** biscyclopentadienyliron, di-2, 4 - cyclopentadien-1-yl iron, ferrocene, iron dicyclopentadienyl.

**PHYSICAL PROPERTIES:** orange, crystalline, solid; camphor-like odor; negligible solubility in water; soluble in benzene, ether and alcohol; forms a deep red solution with blue fluorescence upon dissolution in dilute nitric and concentrated sulfuric acids; practically insoluble.

ble in concentrated boiling hydrochloric acid and 10% sodium hydroxide solution; MP (173°C, 342.5 – 343.4°F); BP (249°C, 480°F); DN/SG (data not available); VD (data not available); VP (data not available).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; organic portions of compound have typical aromatic chemical properties; chemical activity is intermediate between phenol and anisole; undergoes a wide variety of aromatic ring substitution reactions, including Friedel-Crafts acylation, arylation and sulfonation; sublimes above 100°C (212°F); resists pyrolysis at 400°C (752°F); molecule is diamagnetic; dipole moment is effectively zero; not decomposed by high temperature, air, water, dilute acids or bases, when the central metal atom is in a stable oxidation state; FP (data not available); LFL/UFL (data not available); AT (data not available); HC (data not available).

**EXPLOSION and FIRE CONCERNS:** combustible solid; flammable; moderate fire risk; NFPA rating (not rated); volatile in steam; contact with strong oxidizing agents may cause fires and explosions; violent reaction with ammonium perchlorate; incompatible with tetranitromethane and mercury (II) nitrate; thermal decomposition may generate carbon monoxide and carbon dioxide; use alcohol foam, water spray, dry chemical powder, or carbon dioxide for fire fighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); ingestion (damage to the liver, blood changes, testicular changes).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; administer oxygen if breathing is difficult; provide artificial respiration if breathing has stopped; if this chemical has been swallowed, wash out mouth with water and seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** may cause possible irritation of eyes, skin and respiratory system. (Note: The chemical, physical and toxicological properties of this substance have not been thoroughly investigated).

**CHRONIC HEALTH RISKS:** damage to the liver may occur after repeated or prolonged exposure to this chemical; in animals, may cause liver damage, changes in red blood cells (RBC) and testicular changes. (Note: The chemical, physical and toxicological properties of this substance have not been thoroughly investigated).

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including rubber boots, heavy rubber gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where the potential exists for exposures above the permissible exposure level; wear positive pressure self-contained breathing apparatus in unknown concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** sweep-up, place in a bag and hold for waste disposal; if appropriate, moisten first to avoid raising dust; ventilate area and wash spill site after material pickup is complete.

**DISPOSAL AND STORAGE METHODS:** dissolve material in a combustible solvent and burn in chemical incinerator equipped with afterburner and scrubber; disposal should be in accordance with federal, state and local environmental regulations; store in a cool, dry location; maintain adequate ventilation; keep in tightly closed containers; separate from strong oxidizing agents; avoid any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none); label (none).

**OTHER COMMENTS:** Dicyclopentadienyl iron (ferrocene) is an example of a  $\pi$ -bonded organometallic compound. It has been shown to have a doubly  $\pi$ -bonded sandwich structure, consisting of a ferrous iron and two molecules of cyclopentadiene. Dicyclopentadienyl iron, the first organometallic "sandwich" compound, has served as a prototype for metallocenes. Metallocenes are organometallic coordination compounds formed when a transition metal or metal halide is bonded to a cyclopentadienyl ring. This compound has been added to fuel oils to improve efficiency of combustion and to eliminate smoke; has also been used as an antiknock agent for gasoline, as a catalyst and as a coating for missiles and satellites; other uses include that of a high-temperature lubricant, an ultra-violet (UV) absorber and a chemical intermediate in the preparation of high-temperature polymers.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14

### **DIELDRIN (C<sub>12</sub>H<sub>8</sub>Cl<sub>6</sub>O, 380.90)**

**CAS/DOT IDENTIFICATION #:** 60-57-1/UN2761

**SYNONYMS:** heod, 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, exo-5,8-dimethanonaphthalene, illoxol, quintox.

**PHYSICAL PROPERTIES :** colorless to light-tan crystals; mild, chemical odor; moderately soluble in common organic solvents (e.g., acetone, benzene, etc.); practically insoluble in water; insoluble in aliphatic petroleum solvents and methanol; MP (175-176°C, 347-349°F); BP (decomposes); DN (1.62 g/cm<sup>3</sup>); SG (1.75 at 20°C); VD (13.2); VP (8 x 10<sup>-7</sup> mmHg at 77°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; stable in organic and inorganic alkalis; also stable in acids commonly used in agriculture; compatible with most fertilizers, insecticides, herbicides, and fungicides; affected by strong mineral acids; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; reacts vigorously with oxidants, concentrated mineral acids, acid catalysts, and active metals (e.g., sodium, copper, iron); attacks metal due to the slow formation of hydrogen chloride in storage; liquid formulations containing organic solvents may be flammable; explosion hazard will be dependent on the solvent used or on the characteristics of the dust; decomposes on heating producing toxic and corrosive fumes of chlorine and hydrogen chloride; all extinguishing agents are allowed for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (convulsions, dizziness, headache, nausea, vomiting, weakness); skin absorption (sweating, myoclonic limb jerks, respiratory failure); ingestion (symptoms parallel those of inhalation).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, pro-

vide oxygen; if not breathing, provide respiratory support; if ingested, do not induce vomiting and get immediate medical attention.

**HUMAN TOXICITY DATA:** oral-man LDLo 65mg/kg; unknown-human LDLo 28mg/kg; microsomal mutagenicity assay-human fibroblast 1 $\mu$ mol/L; unscheduled dna synthesis-human fibroblast 1 $\mu$ mol/L; dna inhibitor-human hela cell 400 $\mu$ mol/L; oral-unspecified TDLo 21 mg/kg (male 30 W pre); toxic effect: reproductive effects.

**ACUTE HEALTH RISKS:** dizziness; headache; malaise; weakness; nausea; vomiting; tremors; respiratory failure; central nervous system stimulant, resulting in convulsions; sweating; coma.

**CHRONIC HEALTH RISKS:** substance may be found in the human placenta; human mutation data has been reported; kidney and liver damage has been reported in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.25 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.25 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.25 mg/m<sup>3</sup>(skin); IDLH 50 mg/m<sup>3</sup>. (NIOSH considers this substance to be a potential occupational carcinogen).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear chemical safety goggles or face shield; prevent dispersion of dust and avoid exposure to pregnant women; a system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; use self-contained breathing apparatus in oxygen deficient atmospheres.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; carefully collect remainder, then remove to a safe place; this chemical should not be allowed to enter the environment.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; separate from food and feedstuffs.

**REGULATORY INFORMATION:** F4; R3; R4; R5; R7; R8; P waste # (P037); Reportable Quantity (RQ): 1 lb. (0.454 kg); Sf1; CW1; CW2; CW4; CW5; A1; CAL; DOT hazard class/division (6.1); label (poison).

**OTHER COMMENTS:** formerly used as an insecticide; manufacture and use has been discontinued in the United States; use has been restricted to nonagricultural applications.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

### DIETHYLAMINE ((C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>NH, 73.16)

**CAS/DOT IDENTIFICATION #:** 109-89-7/UN1154

**SYNONYMS:** 2-aminopentane, diethamine, n,n-diethylamine, n-ethylethanamine.

**PHYSICAL PROPERTIES :** colorless liquid; fishy, ammonia-like odor; miscible with water and alcohol; soluble in ether, chloroform, paraffin hydrocarbons, aromatic and aliphatic hydrocarbons, fixed oils, mineral oils, oleic and stearic acids; usually supplied as a solution; MP (-50°C, -58°F); BP (55.5°C, 132°F); DN (0.7074 g/mL at 20°C); LSG (0.71); ST (16.4 dynes/cm at 56°C); VS (0.346 cP at 25°C); CP (169.2 J/K-mol liquid at 25°C); HV (31.31

kJ/mol at 25°C); VD (2.53); VP (194 mmHg at 20°C, 400 mmHg at 38.0°C); OT ( $2.0 \times 10^{-2}$  ppm).

**CHEMICAL PROPERTIES:** flammable; strongly alkaline liquid; forms a hydrate  $B_2 \cdot H_2O$ ; may react with acids, strong oxidizers, chlorine, hypochlorite, halogenated compounds, reactive organic compounds and some metals; will attack some forms of plastics, rubber and coatings; FP (-28°C, -18°F); LFL/UFL (1.8%, 10.1%); AT (312°C, 594°F); HC (-716.9 kcal/gmol at 20°C); HF (-103.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 3, Flammability 3, Reactivity 0; very dangerous fire hazard when exposed to heat, flame or oxidizers; flashback along vapor trail may occur; unless diluted extensively, aqueous solutions are flammable; vapor may be explosive if ignited in confined area; explodes on contact with dicyanofurazan; contact with cellulose nitrate of sufficiently high surface area may cause ignition; reacts violently with sulfuric acid; products of decomposition include carbon monoxide, carbon dioxide, hydrocarbons, toxic amine vapors, and toxic oxides of nitrogen; use carbon dioxide, dry chemical, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, nausea, pulmonary edema, chest pains, conjunctivitis); contact (permanent eye injury, necrosis, skin vesiculation).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; conjunctivitis; corneal damage; coughing; nausea; pulmonary edema; asphyxiation.

**CHRONIC HEALTH RISKS:** permanent eye damage; necrosis and vesiculation of skin; myocardial degeneration.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; ACGIH TLV STEL 15 ppm; OSHA PEL TWA 25 ppm ( $75 \text{ mg/m}^3$ ); NIOSH REL TWA 10 ppm ( $30 \text{ mg/m}^3$ ); NIOSH REL STEL 25 ppm ( $75 \text{ mg/m}^3$ ); IDLH 200 ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear rubber overclothing, including gloves; use splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; flush remaining spills with large amounts of water and dilute to form nonflammable mixtures; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** add contaminated amine to layer of sodium bisulfate, spray with water, neutralize, and route to sewage plant; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; absorb in dry earth, sand or vermiculite and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; separate from oxidizing materials, acids, noncombustibles, and sources of halogens.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 100 lbs (45.4kg); Sfl; CW1; CW2; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the rubber and petroleum industry; used as a corrosion inhibitor in iron, steel and metal industries; used as a selective solvent for the removal of impurities from oils, fats, and waxes; useful in flotation agents, dyes, and pharmaceuticals.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 11; 12.

## **2-DIETHYLAMINOETHANOL (C<sub>16</sub>H<sub>15</sub>NO, 117.22)**

**CAS/DOT IDENTIFICATION #:** 100-37-8/UN2686

**SYNONYMS:** deae, diethylaminoethanol, 2-diethylaminoethyl alcohol, n,n-diethylethanolamine, diethylmonoethanolamine, 2-hydroxyethyl diethylamine, 2-hydroxytriethylamine.

**PHYSICAL PROPERTIES :** colorless, hygroscopic liquid; combines the properties of amines and alcohols; nauseating, ammonia-like odor; soluble in alcohol, ether, and benzene; soluble in water; MP(-70°C, -94°F); BP(163°C, 325°F); DN(0.8851 g/mL at 20°C); LSG (0.89); VD(4.03); VP(1.4 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible liquid; can react with oxidizing materials; excessive heat may contribute to instability; FP (60°C, 140°F); LFL/UFL (6.7%, 11.7%); AT (320°C, 608°F).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 1, Flammability 2, Reactivity 0; flammable liquid when exposed to heat or flame; incompatible with strong oxidizers, strong acids, and excessive heat; very corrosive; heating to decomposition emits toxic fumes of oxides of nitrogen; use dry chemical, alcohol foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, vomiting, dizziness, difficult breathing, irritates eyes, skin and respiratory system); contact (severe eye and skin burns).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human T<sub>CLo</sub> 200 ppm; toxic effect: gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; dizziness; nausea; vomiting; pulmonary edema; severe eye and skin burns.

**CHRONIC HEALTH RISKS:** no chronic health risks reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm (skin); OSHA PEL TWA 10ppm (50mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10ppm (50mg/m<sup>3</sup>) (skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; use splash-proof safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb liquid with non-combustible materials (e.g., dry earth, sand or vermiculite), and place in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry location; use only with adequate ventilation; separate from strong oxidizers and strong acids; avoid extreme heat.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as emulsifying agents in acid media; used in textile softeners, pharmaceuticals, and antirust compositions, used in the preparation of water-soluble salts, fatty acid derivatives, and derivatives containing tertiary amine groups; a curing agent for resins.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 14.

### DIFLUORODIBROMOMETHANE (CBr<sub>2</sub>F<sub>2</sub>, 209.83)

**CAS/DOT IDENTIFICATION #:** 75-61-6/UN1941

**SYNONYMS:** dibromodifluoromethane, freon<sup>®</sup> 12B2, halon<sup>®</sup> 1202

**PHYSICAL PROPERTIES:** colorless, clear, heavy liquid; exists in the gaseous state above 75°F; sweet-smelling odor; negligible solubility in water; soluble in methanol, ethyl ether, acetone and benzene; MP (-147°C, -233°F); BP (23.9°C, 75.0°F); DN(2.288 g/mL at 15°C); LSG (2.29 at 15°C); CP (77.0 J/K-mol gas at 25°C); VD (7.2); VP (652 mmHg at 70°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react vigorously with chemically-active metals, such as sodium, calcium, potassium, powdered aluminum, magnesium and zinc; FP (not applicable); LFL/UFL (not applicable); AT (not applicable).

**EXPLOSION and FIRE CONCERNS:** noncombustible liquid; nonflammable gas; NFPA rating (not rated); contact with chemically-active metals (such as potassium (K), sodium (Na), calcium (Ca), powdered aluminum (Al), zinc (Zn) and magnesium (Mg)) will cause fires and explosions; contact with flames and/or hot surfaces will emit hydrogen bromide, hydrogen fluoride, free bromine, and small amounts of carbonyl halides; product is relatively toxic to humans at levels below fire extinguishing concentration; product will not extinguish fires resulting from contact with chemically-active metals; use water spray to cool cylinders involved in fires; use media suitable for flammable materials in area.

**HEALTH SYMPTOMS:** inhalation (drowsiness, loss of consciousness, narcosis, anesthesia, irritates eyes, nose, throat and respiratory system); contact (liquid may cause frostbite); ingestion (cumulative liver damage, central nervous system effects, irregular heartbeat).

**FIRST AID:** flush eyes with copious amounts of water for several minutes; flush affected areas of skin with plenty of water; if frostbite occurs, get medical attention; administer oxygen if breathing is difficult; give artificial respiration if breathing has stopped; if this chemical has been swallowed, seek prompt medical attention. (Note: There is some contradiction as to the usage of the drug epinephrine in treatment of overexposure to this product).

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to nose and throat; drowsiness; unconsciousness; anesthetic effects; liquid can cause frostbite; may lead to dizziness, lack of coordination; cardiac arrhythmias may be noted at high exposure levels.

**CHRONIC HEALTH RISKS:** repeated or prolonged exposure may cause liver damage and central nervous system symptoms; pre-existing heart conditions may be aggravated by exposure to this substance.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm (858 mg/m<sup>3</sup>); OSHA PEL TWA 100 ppm (860 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including rubber boots, neoprene-lined or leather gloves, lab coat, aprons or coveralls; wear chemical safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where the potential exists for exposures above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or if concentrations greater than 1000 ppm are expected; avoid prolonged exposure to excessive concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** evacuate area; ventilate enclosed areas in case of release; use water spray to cool and disperse vapors; if in liquid form, collect for reclamation or absorb in dry sand, earth or vermiculite.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local environmental regulations; store in a cool, dry area; storage area should be well-ventilated; storage temperatures should not exceed 125°F (51.7°C); cylinders should be secured for storage with valve protection cap in place; protect cylinders from physical damage; separate from incompatibles, including chemically-active metals and polymeric materials.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (9); label (none).

**OTHER COMMENTS:** used in the preparation of dyes; used in the synthesis of quaternary ammonium compounds and pharmaceuticals; halon<sup>®</sup>1202 is utilized as a fire extinguishing agent.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

## **DIGLYCIDYL ETHER (C<sub>6</sub>H<sub>10</sub>O<sub>3</sub>, 130.16)**

**CAS/DOT IDENTIFICATION #:** 2238-07-5/none

**SYNONYMS:** bis(2,3-epoxypropyl)ether, dge, diallyl ether dioxide, di(2,3-epoxypropyl)ether, 2-epoxypropyl ether, 2,2'-(oxybis(methylene))bis-oxirane.

**PHYSICAL PROPERTIES:** colorless liquid; strong, pungent odor; solubility data, including water solubility, is unknown in the literature; MP (unknown); BP (260°C, 500°F at 750 mmHg); DN (1.126 g/mL liquid at 25°C); LSG (1.12 at 20°C); VD (3.78 at 25°C); REL DN vapor/air mixture (1.00 at 20°C); VP (0.09 mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; reacts with strong oxidants; FP (64°C, 147°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; forms explosive vapor/air mixtures above 64°C; NFPA rating (not rated); can presumably form explosive peroxides; may explode on heating; can react vigorously with strong oxidizers; hazardous decomposition products include carbon monoxide and carbon dioxide; use powder, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, shortness of breath, sore throat, weakness, unconsciousness); skin contact (dry skin, roughness, skin burns, blisters); eye contact (blurred vision, redness, pain); ingestion (nausea, vomiting, effects on blood, kidneys and liver).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; rinse skin with plenty of water and soap; if breathing is difficult, provide oxygen; if breathing has stopped, provide respiratory support; in case of ingestion, rinse mouth and then give plenty of water to drink; seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** severe irritation of eyes, skin and respiratory tract; pulmonary edema; may cause effects on the blood, kidneys, liver and testes; dizziness; shortness of breath; sore throat; weakness; blurred vision; skin burns; nausea; vomiting; unconsciousness.

**CHRONIC HEALTH RISKS:** prolonged contact with skin may cause dermatitis; repeated or prolonged contact may cause skin sensitization; can cause bone marrow depression; based on testing in animals, may possibly cause toxic effects upon human reproduction.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (0.53 mg/m<sup>3</sup>); OSHA PEL CL 0.5 ppm (2.8 mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.5 mg/m<sup>3</sup>) potential occupational carcinogen; IDLH 10 ppm potential occupational carcinogen.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles or face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; collect spilled liquid in sealable containers or absorb with inert materials (e.g., dry earth, sand, or vermiculite); wash away remainder with plenty of water.

**DISPOSAL AND STORAGE METHODS:** may be disposed in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation along the floor; separate from strong oxidants.

**REGULATORY INFORMATION:** Sf2; A1; CAL; DOT classification (none); labels (none).

**OTHER COMMENTS:** may be used as a chemical intermediate; besides the risk of explosion from air mixtures, this substance may possibly form peroxides upon standing; hence, it is necessary to check for peroxides prior to distillation and eliminate if found.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

### DIISOBUTYL KETONE ( $[(\text{CH}_3)_2\text{CHCH}_2]_2\text{CO}$ , 142.27)

**CAS/DOT IDENTIFICATION #:** 108-83-8/UN1157

**SYNONYMS:** dibk, sym-diisopropyl acetone, 2,6-dimethyl-4-heptanone, 2,6-dimethylheptan-4-one, isovalerone, valerone.

**PHYSICAL PROPERTIES** : water clear liquid; mild, sweet odor; soluble in alcohol, chloroform and ether; miscible with benzene; immiscible with water; MP (-41.5°C, -42.7°F); BP (168°C, 334°F); DN (0.8053 g/mL at 20°C); LSG (0.81); ST (23.92 dynes/cm at 22°C); VS (0.896 cP at 70°C); CP (297.3 J/K-mol liquid at 25°C); HV (50.92 kJ/mol at 25°C); VD (4.9); VP (1.7 mmHg at 20°C).

**CHEMICAL PROPERTIES**: combustible liquid; very stable; can react with oxidizing materials; FP (60°C, 140°F); LFL/UFL (0.8% at 200°F, 7.1% at 200°F); AT (396°C, 745°F); HC (-16,040 Btu/lb, -8,910 cal/g, -373 x 10<sup>5</sup> J/kg); HF (-408.5 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS**: combustible; NFPA rating Health 1, Flammability 2, Reactivity 0; flammable liquid when exposed to heat or flame; incompatible with strong oxidizers; heating to decomposition emits acrid smoke and fumes; use carbon dioxide, dry chemical, foam, water spray, mist or fog for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (headache, nausea, vomiting, unspecified eye effects, irritates nose and throat); ingestion (irritates mouth and stomach); contact (liquid irritates skin, dermatitis).

**FIRST AID**: wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink plenty of water or milk.

**HUMAN TOXICITY DATA**: eye-human 25 ppm/15M; toxic effect: mild irritation effects; inhalation-human TCLo 50 ppm; toxic effect: eye, central nervous system, gastrointestinal tract.

**ACUTE HEALTH RISKS**: irritation of eyes, nose and throat; headache; dizziness; coughing; difficult breathing; nausea; vomiting; narcotic effects; irritation of mouth and stomach; skin irritation; convulsions; loss of consciousness.

**CHRONIC HEALTH RISKS**: liver damage; damage to the kidneys; dermatitis.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 25 ppm; OSHA PEL TWA 50 ppm (290mg/m<sup>3</sup>); NIOSH REL TWA 25 ppm (150 mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION**: appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear full protective clothing, including plastic gloves; use splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP**: use water spray to cool and disperse vapors; flush remaining ketone with large amounts of water, and dilute spills to form nonflammable mixtures.

**DISPOSAL AND STORAGE METHODS**: dissolve in flammable solvent (such as alcohol) and burn in incinerator equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; outside storage is preferred; store away from oxidizers.

**REGULATORY INFORMATION**: A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS**: used as a solvent for nitrocellulose, rubber, synthetic resins, lacquers and synthetic coatings; chemical intermediate in the organic synthesis of pharmaceuticals, dyes and inhibitors; also used as a dewaxing agent for lubricating oils and in the separation of tantalum and niobium.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 11; 12; 14.

**DIISOPROPYLAMINE**( $[(\text{CH}_3)_2\text{CH}]_2\text{NH}$ , 101.22)

**CAS/DOT IDENTIFICATION #:** 108-18-9/UN1158

**SYNONYMS:** dipa, n-(1-methylethyl)-2-propanamine.

**PHYSICAL PROPERTIES:** colorless to pale yellow liquid; ammonia or fish-like odor; slightly soluble in water; soluble in ethanol, ether, acetone, and benzene; MP (-61°C, -77.8°F); BP (84°C, 183°F); DN (0.7178 g/mL at 20°C); LSG (0.72); ST (19.64 dynes/cm at 20°C); VS (0.393 mPa-s at 25°C); HV (34.61 kJ/mol at 25°C); VD (3.5); VP (60 mmHg at 20°C).

**CHEMICAL PROPERTIES:** flammable liquid; strongly alkaline; volatile; can react vigorously with oxidizing materials; reacts with strong alkalies; FP (-6°C, 21°F); LFL/UFL (1.1%, 7.1%); AT (316°C, 600°F); HC (-11,000 cal/g); HF (-178 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable; very dangerous fire hazard when exposed to heat or flame; NFPA rating Health 3, Flammability 3, Reactivity 0; flashback along vapor trail may occur; vapor may explode if ignited in a confined area; incompatible with strong oxidizers and strong acids; heating to decomposition emits toxic fumes of oxides of nitrogen; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, difficult breathing, nausea, vomiting, pulmonary edema, burns to the respiratory system, irritates eyes, nose and throat); ingestion (irritates mouth and stomach); contact (causes severe burns, irritates skin).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support; if ingested, induce vomiting by giving a large volume of warm salt water.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; nausea; vomiting; headache; visual disturbances; coughing; difficult breathing; pulmonary edema; irritation of mouth and stomach; convulsions; loss of consciousness.

**CHRONIC HEALTH RISKS:** no chronic health risks reported in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm(skin); OSHA PEL TWA 5 ppm (2mg/m<sup>3</sup>)(skin); NIOSH REL TWA 5 ppm (20 mg/m<sup>3</sup>)(skin); IDLH 200 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, including plastic gloves and rubber aprons; use self-contained breathing apparatus and splash-proof safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; flush remaining diisopropylamine with large amounts of water and dilute to form nonflammable mixtures; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** add contaminated amine to layer of sodium bisulfate, spray with water, neutralize, and route to sewage plant; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; separate from acids and oxidizing agents.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a chemical intermediate for diisopropylammonium nitrate and n,n-diisopropyl-2-benzothiazole-sulfenamide; also useful as a catalyst.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 11; 12.

#### **4-DIMETHYLAMINOAZOBENZENE (C<sub>6</sub>H<sub>5</sub>NNC<sub>6</sub>H<sub>4</sub>N(CH<sub>3</sub>)<sub>2</sub>, 143.0)**

**CAS/DOT IDENTIFICATION #:** 60-11-7/

**SYNONYMS:** butter yellow, DAB, p-dimethylaminoazobenzene, N,N-dimethyl-4-aminoazobenzene, methyl yellow.

**PHYSICAL PROPERTIES :** yellow, leaf-shaped crystals; aromatic odor; chloroform-like odor; soluble in alcohol, benzene, chloroform, ether, petroleum ether, mineral acids, and oils, insoluble in water; MP (114-117°C, 237-243°F); DN (1050kg/m<sup>3</sup>); SG (1.05); VP (3.3 x 10<sup>-7</sup> mmHg at 25°C).

**CHEMICAL PROPERTIES:** derived by the action of benzenediazonium chloride on dimethyl aniline; will not polymerize; incompatible with strong acids and strong oxidizing agents.

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); reacts violently with strong oxidizers; when heated to decomposition, emits toxic fumes of carbon dioxide, carbon monoxide and oxides of nitrogen; use water spray, dry chemical, carbon dioxide, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, wheezing, difficulty breathing); skin absorption (skin rashes, burning sensation).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** dni-human hla 100µmol/L; United States EPA has not established a reference dose.

**ACUTE HEALTH RISKS:** irritation of skin; enlarged liver; liver and kidney dysfunction; coughing; wheezing; difficulty breathing; bloody sputum; bronchial secretions; frequent urination; blood in the urine..

**CHRONIC HEALTH RISKS:** probable cancer causing agent in humans; reproductive effects; contact dermatitis; liver damage; kidney and bladder effects.

**EXPOSURE GUIDELINES:** OSHA PEL Cancer Suspect Agent; NIOSH REL TWA use 29 CFR 1910.1015.

**PERSONAL PROTECTION:** wear special protective clothing; chemical-resistant rubber gloves are recommended; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as vermiculite, dry earth or sand; ventilate area of spill or leak.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; collect spilled material and deposit in tightly sealed containers for disposal in an approved facility; dissolve in a flammable solvent and atomize in an incinerator equipped with afterburner and scrubber; store in a cool, dry, well-ventilated area; keep containers tightly closed.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf3; CAL.

**OTHER COMMENTS:** used as a pH indicator; used in the spot test identification for peroxidized fats; used in dyes, soap, wax products, and polystyrene; used in organic research

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 12; 14.

### **DIMETHYLACETAMIDE (CH<sub>3</sub>CON(CH<sub>3</sub>)<sub>2</sub>, 87.14)**

**CAS/DOT IDENTIFICATION #:** 127-19-5/none

**SYNONYMS:** acetic acid dimethylamide, acetyl dimethylamide, n,n-dimethylacetamide, dimethylacetone amide, dimethylamide acetate, dmac.

**PHYSICAL PROPERTIES :** oily, colorless liquid; weak, ammonia- or fish-like odor; miscible in water; miscible with most aromatic compounds, esters, ketones, and ethers; soluble in water, alcohol, acetone, benzene, and ether; MP (-20°C, -4°F); BP (166°C, 331°F at 760 mmHg); DN (0.9366 g/mL at 25°C); LSG (0.94); ST (34 dynes/cm at 20°C); VS (0.92 cP at 25°C); CP (175.6 J/K-mol liquid at 25°C); HV (50.24 kJ/mol at 25°C); VD (3.01); REL DN vapor/air mixture (1.01 at 20°C); VP (1.5 mmHg at 20°C); OT (21.4 ppm for 50% response, 46.8 ppm for 100% response).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; attacks plastic and rubber; can react with oxidizing agents; FP (70°C, 158°F); LFL/UFL (1.8% at 100°C, 11.5% at 160°C); AT (490°C, 914°F); HC (-6,980 cal/g); HF (-278.3 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid and vapor; moderately explosive; NFPA rating Health 2, Flammability 2, Reactivity 0; may form explosive vapor/air mixtures above 70°C; flashback along vapor trail may occur; sealed containers may rupture when heated; temperatures above 350°C (622°F) cause decomposition and development of pressure in closed containers; contact with strong oxidizers may cause fire; reacts violently with halogenated compounds (e.g., carbon tetrachloride, hexachlorocyclohexane), when heated above 90°C (194°F); incompatible with iron plus halogenated compounds when heated to 71°C (160°F); decomposes on heating producing toxic fumes of oxides of nitrogen; burning may also produce carbon monoxide, carbon dioxide, ammonia, and dimethylamine; use dry chemical, foam or carbon dioxide for firefighting purposes; halogenated extinguishing media should not be used; direct stream of water can scatter and spread flames.

**HEALTH SYMPTOMS:** inhalation (cough, shortness of breath, irritates respiratory tract, headache, nausea, vomiting); skin absorption (headache, nausea, lethargy, delusions, hallucinations); skin contact (redness, itching, pain, liquid defats skin); ingestion (abdominal cramps, nausea, vomiting, diarrhea, kidney damage, depression, disorientation, perceptual distortions, sweating, weakness, yellow jaundice).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush affected areas of skin with plenty of soap and water; if breathing is difficult, remove to

fresh air and provide oxygen; if not breathing, give artificial respiration; in case of ingestion, give large amounts of water to drink and get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** mild irritation of skin and eyes; irritation to the respiratory tract; coughing; shortness of breath; headache; abdominal pain; nausea; vomiting; sweating; weakness; diarrhea; depression; lethargy; disorientation visual and auditory hallucination; delusions; perceptual distortions; emotional detachment; kidney damage.

**CHRONIC HEALTH RISKS:** liver damage with yellow jaundice; may have effects on the central nervous system; liquid may cause defatting of skin; reproductive effects have been induced in laboratory animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (36 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 10 ppm (35 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10 ppm (35 mg/m<sup>3</sup>)(skin); IDLH 300 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; butyl rubber is the recommended material for gloves and clothing; use chemical safety goggles where splashing is possible; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use self-contained breathing apparatus if the exposure limits is exceeded; use non-sparking type tools and explosion-proof equipment; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect spilled liquid in sealable containers; absorb remaining liquid with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush spill area with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or other inert absorbent, and place in sealed containers in a secured, sanitary landfill; atomize in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; keep in tightly closed containers; protect against physical damage; isolate from incompatible substances and from any source of heat or ignition.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a solvent in many industrial applications and for numerous organic reactions; also used as a solvent for plastics, gums, resins, and electrolytes; useful as a catalyst, paint remover, and as a high purity solvent for purification and crystallization.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 11; 14.

### **DIMETHYLAMINE ((CH<sub>3</sub>)<sub>2</sub>NH, 45.10)**

**CAS/DOT IDENTIFICATION #:** 124-40-3/UN1032 (anhydrous), UN1160 (solution).

**SYNONYMS:** dma, n-methylmethanamine.

**PHYSICAL PROPERTIES :** colorless gas (anhydrous) at ordinary temperatures; ammonia- or fish-like odor; may be in water solution as shipped or used; anhydrous material floats and boils on water upon mixing; soluble in alcohol and ether; very soluble in water, forming very strong alkaline solutions; MP (-92°C, -134°F); BP (7°C, 44°F); DN (0.680 g/mL liquid at 0°C); LSG (0.68 at 32°F, 0.67 at 44°F); ST (18.1 dynes/cm, 17.7 dynes/cm in contact

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with nitrogen at 0°C and 5°C, respectively); CP (137.7 J/K-mol liquid at 25°C); VD (1.56); VP (1500 mmHg at 25°C); OT (23.2 ppm in water).

**CHEMICAL PROPERTIES:** flammable gas or liquid; may react with acids, oxidizing materials, chlorine, hypochlorite, halogenated compounds, reactive organic compounds, and some chemically active metals; reaction with mercury and nitrosating compounds; FP (NA gas; -6.7°C, 20°F liquid); LFL/UFL (2.8%, 14.4%); AT (430°C, 806°F); HC (-416.7 kcal/gmol at 20°C); HF (-43.9 kJ/mol liquid at 25°C, -18.5 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 3, Flammability 4, Reactivity 0; flashback along vapor trail may occur; explosive if ignited in a confined area; aqueous solutions are flammable unless extensively diluted; incompatible with fluorine, maleic anhydride, and acrylaldehyde; heating to decomposition emits carbon monoxide, carbon dioxide, hydrocarbons, toxic amine vapors, and toxic oxides of nitrogen; use water spray, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, nausea, pulmonary edema, irritates nose and throat); contact (conjunctivitis, corneal damage, sneezing, dyspnea, dermatitis, liquid may cause frostbite).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of nose and throat; burns to skin and mucous membranes; conjunctivitis; sneezing; coughing; difficult breathing; pulmonary edema.

**CHRONIC HEALTH RISKS:** possibility of permanent eye damage; dermatitis; may alter genetic material.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; ACGIH TLV STEL 15 ppm; OSHA PEL TWA 10 ppm (18mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (18 mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear rubberized outerwear and molded rubber acid gloves; wear chemical safety goggles and self-contained breathing apparatus; equipment should not have copper alloys, zinc, aluminum or galvanized parts.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures, and then neutralize diluted pools with five percent sulfuric acid; absorb spills involving aqueous solutions in noncombustible materials such as dry earth, sand or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** add contaminated amine to layer of sodium bisulfate, spray with water, neutralize, and route to sewage plant; dissolve in flammable solvent (such as alcohol) and burn in an incinerator equipped with afterburner and scrubber; absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; flush remaining dimethylamine with large amounts of water but not into confined spaces such as sewers because of danger of explosion; store in a cool, dry location with adequate ventilation; avoid oxidizing materials, sources of halogens, acids, and chemically active metals.

**REGULATORY INFORMATION:** U waste# (U092); Reportable Quantity (RQ): 1000 lbs (454kg); Sf1; Sf3; CW1; CW2; A1; A5; CAL; DOT hazard class/division (2.1); labels (flammable gas, UN1032); DOT hazard class/division (3); labels (flammable liquid, UN1160).

**OTHER COMMENTS:** used as an accelerator in the vulcanization of rubber; used in the manufacture of dimethylformamide and dimethylacetamide; use as a reagent for magnesium; useful as a flotation agent, an acid-gas absorbent, gasoline stabilizers, surfactants, rocket propellants, and as missile fuels; also used in the manufacture of detergent soaps, and in the pharmaceutical, textile and electroplating industries.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 11; 12.

**DIMETHYLANILINE (C<sub>6</sub>H<sub>5</sub>N(CH<sub>3</sub>)<sub>2</sub>, 121.20)**

**CAS/DOT IDENTIFICATION #:** 121-69-7/UN2253

**SYNONYMS:** benzenamine, N,N-dimethylaniline, N,N-dimethylbenzeneamine, N,N-dimethylphenylamine.

**PHYSICAL PROPERTIES :** pale-yellow, oily liquid; exists as a solid below 36°F; amine-like odor; freely soluble in alcohol, chloroform and ether; insoluble in water; MP (2.5°C, 36.5°F); BP (192.5-193.5°C, 378.5-380°F); DN (0.9557 g/mL at 20°C); LSG (0.96); ST (35.52 mN/m at 298.15K); VS (1.300 mPa-s at 298.15K); CP (199.1 J/gmol-K liquid at 25°C); HV (52.83 kJ/gmol); VD (4.2); VP (1 mmHg at 30°C, 10 mmHg at 70°C); OT (0.013 ppm).

**CHEMICAL PROPERTIES:** generally stable; will not polymerize; reacts with strong oxidizers, strong acids and benzoyl peroxide; reacts strongly with acid chlorides, acid anhydrides, chloroforms, and halogens; FP (62.7°C, 145°F); LFL/UFL (1.0%, 6.4%); AT (370°C, 700°F); HC (-4525 kJ/mol); HF (100.5 kJ/gmol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** dangerous fire hazard; NFPA rating Health 3, Flammability 2, Reactivity 0; explodes on contact with benzoyl peroxide or diisopropyl peroxydicarbonate; incompatible with acid chlorides, acid anhydrides, chloroformates, halogens, strong acids, and oxidizing agents; decomposition emits highly toxic fumes of aniline, carbon monoxide, carbon dioxide, and oxides of nitrogen; use carbon dioxide, dry chemical powder, water spray, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, mucous membranes); skin absorption (headaches, dizziness, labored breathing, weakness, blood disorders).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 50 mg/kg; toxic effect: gastrointestinal tract; EPA Cancer Risk Level not classified

**ACUTE HEALTH RISKS:** irritation of skin, eyes, mucous membranes, and upper respiratory tract; headaches; weakness; dizziness; cyanosis; labored breathing; paralysis; convulsions; tremors; serious damage to eyes.

**CHRONIC HEALTH RISKS:** central nervous system effects; blood disorders (increased methemoglobin; decreased hemoglobin concentration); enlargement of spleen; hemosiderosis of liver, kidneys and testes; suspected carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; STEL 10 ppm (skin); OSHA PEL TWA 5 ppm (25 mg/m<sup>3</sup>); STEL 10 ppm (skin); NIOSH REL TWA 5 ppm (25 mg/m<sup>3</sup>); STEL 10 ppm (50 mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

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**PERSONAL PROTECTION:** wear rubber apron, sleeves, and other protective clothing; wear rubber or neoprene gauntlet gloves; chemical safety goggles are recommended; wear an appropriate self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to reduce vapors; absorb as much as possible with sand or other noncombustible absorbent material and place into container for later disposal; flush area with water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry, well-ventilated flammable liquid storage area or cabinet; keep container tightly closed.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 1 lb (0.454kg); Sf3; A1; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of vanillin, Micher's ketone, methyl violet, and other dyes; used as a reagent for methanol, methyl furfural, hydrogen peroxide, nitrate, alcohol, and formaldehyde.

**KEY REFERENCES:** 1; 2; 3; 4; 5; 6; 7; 8; 9; 12; 13; 14.

### **DIMETHYL-1,2-DIBROMO-2,2-DICHLOROETHYL PHOSPHATE (C<sub>4</sub>H<sub>7</sub>Br<sub>2</sub>Cl<sub>2</sub>O<sub>4</sub>P, 380.80)**

**CAS/DOT IDENTIFICATION #:** 300-76-5/UN3018

**SYNONYMS:** bromex<sup>®</sup>, dibrom<sup>®</sup>, 1,2-dibromo-2,2-dichloroethyl dimethyl phosphate, naled, orthodibrom<sup>®</sup>

**PHYSICAL PROPERTIES :** colorless to white solid or straw-colored liquid; slightly pungent odor; exists as a liquid above 80°F; insoluble in water; very soluble in aromatic and chlorinated hydrocarbons, ketones and alcohols; sparingly soluble in petroleum solvents and mineral oils; MP (26.5-27.5°C, 79.7-81.5°F); BP (110°C, 230°F at 0.5 mmHg); DN (1.96 g/mL at 25°C); LSG (1.96 at 25°C); VP (2 x 10<sup>-3</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; completely hydrolyzed in presence of water within 48 hrs; attacks metal, plastic, rubber and coatings; can react with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; liquid formulations containing organic solvents may be flammable; solvent used in the formulation will determine the explosion hazard; hydrolyzed by water and alkalis and degraded by sunlight; corrosive to metals; decomposes on heating or on burning, producing toxic and corrosive fumes of hydrogen chloride, hydrogen bromide, and phosphorus oxides; in case of fire in the surroundings, use all extinguishing agents for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (labored breathing, dizziness, cough, wheezing, excessive salivation, muscle cramp, chest tightness, lacrimation, laryngitis, nausea, vomiting, pupillary constriction, unconsciousness); skin absorption (paralysis, giddiness, twitching, ataxia, convulsions, respiratory failure); skin contact (redness, burning sensation, skin sensitization, dermatitis); eye contact (redness, pain, blurred vision); ingestion (abdominal cramps, nausea, vomiting, diarrhea, labored breathing, blurred vision).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; provide artificial respiration if indicated; in case of ingestion, induce vomiting; get immediate medical attention.

**HUMAN TOXICITY DATA:** skin-man 42 mg/21D-intermittent.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; dizziness; headache; labored breathing; wheezing; excessive salivation; chest tightness; lacrimation; cyanosis; laryngeal spasm; muscle cramps; pupillary constriction; twitching; paralysis; giddiness; ataxia; convulsions; cardiac irregularities; abdominal cramps; nausea; vomiting; diarrhea; burning sensation; respiratory failure; inhibits cholinesterase.

**CHRONIC HEALTH RISKS:** prolonged contact may cause dermatitis and skin sensitization; cholinesterase inhibitor; low blood pressure; anorexia; cumulative effect of acute hazards is possible.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 3 mg/m<sup>3</sup>(skin); OSHA PEL TWA 3 mg/m<sup>3</sup>; NIOSH REL TWA 3 mg/m<sup>3</sup>(skin); IDLH 200 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; use a closed system of local exhaust ventilation to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect spilled liquid in sealable containers or absorb with noncombustible materials (e.g., dry earth, sand, vermiculite); flush remaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of in accordance with federal, state and local regulations; store in a cool, dry location; use only with adequate ventilation; keep in the dark; separate from strong oxidizers, acid, metals, food and feedstuffs.

**REGULATORY INFORMATION:** F2; F5; Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf3; CW1; CW2; A1; CAL.

**OTHER COMMENTS:** used as an insecticide and an acaricide; this substance may be hazardous to the environment; special attention should be give to aquatic life.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

## **DIMETHYL FORMAMIDE (HCON(CH<sub>3</sub>)<sub>2</sub>, 73.1)**

**CAS/DOT IDENTIFICATION #:** 68-12-2/UN2265

**SYNONYMS:** dimethyl formamide, N,N-dimethyl formamide, DMF, N-formyldimethylamine.

**PHYSICAL PROPERTIES :** colorless to very slightly yellow liquid; fishy or faint amine-like odor; a dipolar aprotic solvent; miscible in water, ethanol, diethyl ether, benzene, and chloroform; MP(-61°C, -78°F); BP(152.8°C, 307°F); DN(0.945 g/mL at 25°C); LSG (0.95);

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VS(0.794 mPa-s at 298.15 K); CP(150.6 J/mol-K liquid at 298.15 K); HV (46.89 kJ/mol at 298.15 K); VD(2.51); VP(3.7 mmHg at 25°C); OT (2.2 ppm).

**CHEMICAL PROPERTIES:** combustible liquid; reacts strongly with carbon tetrachloride, strong oxidizers, alkyl aluminums, and inorganic nitrates; reacts with halogenated compounds when in contact with iron; FP (136°C, 277°F); LFL/UFL (2.2%, 15.2%); AT (445°C, 833°F); HF (-239.3 kJ/mol liquid at 298.15 K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid when exposed to heat or flame; NFPA rating Health 1, Flammability 2, Reactivity 0; explosion hazard when exposed to flame, reacts violently with bromine, potassium permanganate, triethylaluminum + heat; forms explosive mixtures with lithium azide and uranium perchlorate; ignites on contact with chromium trioxide; violent reaction with chlorine, sodium hydroborate + heat, diisocyanatomethane, carbon tetrachloride + iron, 1,2,3,4,5,6-hexachlorocyclohexane + iron; vigorous exothermic reaction with magnesium nitrate, sodium + heat, sodium hydride + heat sulfinyl chloride + traces of iron or zinc, and 2,4,6-trichloro-1,3,5-triazine, incompatible with halogenated hydrocarbons, inorganic and organic nitrates, and methylene diisocyanates; decomposition emits toxic fumes of NO<sub>x</sub>; use dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin contact (nausea, vomiting, headache, loss of appetite, defatting of skin, facial flushing); eye contact (irritation, redness, burning, tears).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** skin-human 100%/24H; toxic effect: mild irritation effects; cytogenetic-human lymphocyte 100 nmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes, and respiratory system; nausea; vomiting; jaundice; liver damage; enlarged liver; high blood pressure; facial flush; alcohol intolerance; skin rashes.

**CHRONIC HEALTH RISKS:** liver damage; minimal hepatic changes; liver abnormalities, digestive disturbances; increased rate of spontaneous abortion; cancer of the pharynx.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm (skin); OSHA PEL TWA 10ppm (30mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10ppm (30mg/m<sup>3</sup>) (skin); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear a gas-tight suit; wear chemical safety goggles; wear compressed air/oxygen apparatus.

**SPILL CLEAN-UP:** use water spray to reduce vapors; take up with sand or other non-combustible absorbent material and place into container for later disposal; flush area with large amounts of water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb with sand or inert material, and place in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry, well-ventilated flammable liquid storage area or cabinet; keep containers tightly closed.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf3; DOT hazard class/division (3) labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for liquids and gases; used as a solvent for orlon and similar polyacrylic fibers; has been termed the universal organic solvent; used in the

manufacture of polymer fibers, films, surface coatings, and wire enamels; used as a crystallization medium in pharmaceutical industry.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 12; 13; 14.

**1,1-DIMETHYLHYDRAZINE ((CH<sub>3</sub>)<sub>2</sub>NNH<sub>2</sub>, 60.1)**

**CAS/DOT IDENTIFICATION #:** 57-14-7/UN1163

**SYNONYMS:** dimazine, N,N-dimethylhydrazine, unsymmetrical dimethylhydrazine, DMH, UDMH.

**PHYSICAL PROPERTIES :** clear, colorless, fuming liquid; gradually turns yellow upon contact with air; ammonia or fish-like odor; miscible with ethanol, dimethylformamide, and hydrocarbons; completely soluble in water; negligible solubility in ether; MP (-58°C, -72°F); BP (64°C, 147°F); DN (0.791 g/cm<sup>3</sup> at 22°C); LSG (0.79); CP (164.1 J/mol-K liquid at 298.15K); HV (35 kJ/mol at 298.15 K); VD (1.94); VP (103 mmHg at 20°C, 566 mmHg at 55°C); OT (1.7 ppm).

**CHEMICAL PROPERTIES:** stable; will not polymerize; hygroscopic liquid; powerful reducing agent; reacts vigorously with oxidizing materials, halogens, metallic mercury, fuming nitric acid, and hydrogen peroxide; corrosive; FP (-15°C, 5°F); LFL/UFL (2%, 95%); AT (249°C, 480°F); HF (48.9 kJ/mol liquid at 298.15 K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; dangerous fire hazard; NFPA rating Health 3, Flammability 3, Reactivity 1; ignites spontaneously with many oxidants (dinitrogen tetroxide, hydrogen peroxide, and nitric acid); reacts vigorously with air and fuming nitric acid; exposure to the atmosphere results in the formation of the carcinogen 1,1-dimethylnitrosamine; vapors are heavier than air and may cause flashback by traveling to the ignition sources; mixes with air to form flammable and/or explosive mixtures; liberates heat on contact with water; incompatible with copper, copper alloys, brass, iron, and iron salts; combustion by-products include oxides of nitrogen, carbon dioxide, and carbon monoxide; use water spray, dry chemical, alcohol resistant foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nose and throat irritation, mild conjunctivitis, headache, nausea, vomiting, shortness of breath); skin absorption (irritates skin, eyes, and mucous membranes, causes skin burns).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** otr-human fibroblast 167µmol/L; dnd-human fibroblast 300µmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, throat, and mucous membranes; coughing; laryngitis; shortness of breath; headaches; nausea; vomiting; chest pains; convulsions; central nervous system stimulation.

**CHRONIC HEALTH RISKS:** liver damage in humans; gastrointestinal disturbances; alters genetic material; probable human carcinogen; reference dose not established by EPA.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (skin); OSHA PEL TWA 0.5 ppm (1mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.15 mg/m<sup>3</sup>/2H; IDLH 15 ppm..

**PERSONAL PROTECTION:** wear boots, apron, chemical-resistant gloves, and chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; absorb as much as possible with noncombustible materials such as dry earth or sand; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in a sanitary landfill; store in a cool, dry, well-ventilated location; inside storage should be in a standard flammable liquids storage room or cabinet; store under nitrogen in a tightly sealed container away from oxidizing materials, strong acids, halogens, and copper, iron, and mercury metals and compounds.

**REGULATORY INFORMATION:** CA2; R4; U waste # (U098); Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf2; Sf3; A1; CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid, corrosive).

**OTHER COMMENTS:** used as a component of jet and rocket fuels; used as a source of high-energy fuel in military applications; used as an absorbent for acid gases.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14.

### **DIMETHYLPHTHALATE (C<sub>6</sub>H<sub>4</sub>(COOCH<sub>3</sub>)<sub>2</sub>, 194.20)**

**CAS/DOT IDENTIFICATION #:** 131-11-3/UN9188

**SYNONYMS:** avolin, 1,2-benzenedicarboxylic acid, dimethyl-1,2-benzenedicarboxylate, dimethyl ester of 1,2-benzenedicarboxylic acid, DMP, methyl phthalate.

**PHYSICAL PROPERTIES :** colorless, oily liquid; slight aromatic odor; miscible with alcohol, ether and chloroform; practically insoluble in water, petroleum ether, and other paraffin hydrocarbons; slightly soluble in mineral oil; MP (0°C, 32°F); BP (282.4°C, 540.3°F); DN (1.189 g/mL at 25°C); LSG (1.19); VS (17.2 cP at 25°C); HV (93.1 gcal/g); VD (6.69); VP (4.19 x 10<sup>-3</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible liquid; reacts with nitrates, strong oxidizers, alkalies, and acids; FP (146°C, 295°F); LFL/UFL (0.94%, 8.03%); AT (555.6°C, 1032°F); HC (119.7 kcal/mole).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating Health 0, Flammability 1, Reactivity 0; reacts vigorously with oxidizing materials; decomposition products include carbon monoxide and carbon dioxide; when heated to decomposition emits acrid smoke and irritating fumes; use carbon dioxide and dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and mucous membranes); ingestion (central nervous system depression, headache, nausea, vomiting, burning sensation).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** no information is available for toxic effects in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and mucous membranes; irritation of upper respiratory tract; stomach pain; nausea; vomiting; kidney effects; bladder changes; hallucinations; central nervous system depression.

**CHRONIC HEALTH RISKS:** no information is available on the chronic effects in humans; may cause respiratory disorders; EPA Group D: not classifiable as to human carcinogenicity.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; IDLH 2000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear special protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb liquid with non-combustible materials (e.g., dry earth, sand or vermiculite), and place in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; separate from incompatibles; avoid heat, sparks, and open flame.

**REGULATORY INFORMATION:** CA2; R3; R4; R5; R9; U waste # (U102); Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sf1; Sf3; CW4; CW5; T799-5000; A1; CAL.

**OTHER COMMENTS:** used as a solvent and plasticizer for cellulose acetate and cellulose acetate-butyrate compositions; used as an insect repellent for personal protection against biting insects; also used as a rubber coating agent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 13; 14.

**DIMETHYL SUFLATE** ((CH<sub>3</sub>)<sub>2</sub>SO<sub>4</sub>, 126.1)

**CAS/DOT IDENTIFICATION #:** 77-78-1/UN1595

**SYNONYMS:** dimethyl ester of sulfuric acid, dimethyl monosulfate, DMS, methyl sulfate.

**PHYSICAL PROPERTIES :** colorless, oily liquid; faint, onion-like odor; soluble in diethyl ether, acetone, dioxane, and aromatic hydrocarbons; slightly soluble in hexane, ethanol, and benzene; slightly soluble in water; MP (-32°C, -25°F); BP (188°C, 370°F); DN (1.322 g/cm<sup>3</sup> at 15°C); LSG (1.33); VD (4.35); VP (0.5 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible; reacts with strong oxidizers, strong bases, and ammonia solutions; corrodes steel when wet; decomposes in water to sulfuric acid; FP (83°C, 182°F); AT (188°C, 370°F).

**EXPLOSION and FIRE CONCERNS:** flammable when exposed to heat, flame, or oxidizers; NFPA rating Health 4, Flammability 2, Reactivity 0; reacts strongly with oxidizing materials; reacts violently with ammonium hydroxide and sodium azide; may decompose on exposure to moist air or water; decomposition products are carbon monoxide, carbon dioxide, and sulfur oxides; decomposition emits toxic fumes of SO<sub>x</sub>; use dry chemical, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, nose, throat, larynx, and trachea); contact (skin ulcerations, necrosis, reddening of the skin).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 97ppm/10M; dnd-human lymphocyte 1mmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; headache; vomiting; diarrhea; coughing; chest pain; giddiness; photophobia; periorbital edema; dysphagia; hematuria (blood in urine); delirium; paralysis; damage to the lungs; injures the liver and kidneys; damage to the heart; central nervous system effects; convulsions; coma; death.

**CHRONIC HEALTH RISKS:** serious injury to liver and kidneys; pulmonary edema; jaundice; prostration; suppression of urine; albuminuria; hematuria; cornea damage; EPA Group B2 probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (skin); OSHA PEL TWA 0.1 ppm (skin); NIOSH REL TWA 0.1 ppm (0.5mg/m<sup>3</sup>)(skin); IDLH 7 ppm.

**PERSONAL PROTECTION:** wear special protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; prompt cleanup and removal are necessary.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in a sanitary landfill; dissolve in a flammable solvent and ignite in an incinerator equipped with afterburner and scrubber; storage should be in tightly sealed containers away from heat and open flame; separate from oxidizing materials, bases, water, and metal.

**REGULATORY INFORMATION:** CA2; R4; U waste # (U103); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf2; Sf3; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (poison, corrosive).

**OTHER COMMENTS:** used as a methylating agent in the manufacture of many organic chemicals; used in the manufacture of dyes, perfumes, and adhesives; used in the separation of mineral oils; also used in the analysis of auto fluids.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 12; 13; 14.

### **ORTHO-DINITROBENZENE (C<sub>6</sub>H<sub>4</sub>(NO<sub>2</sub>)<sub>2</sub>, 168.12)**

**CAS/DOT IDENTIFICATION #:** 528-29-0/UN1597

**SYNONYMS:** o-dinitrobenzene, 1,2-dinitrobenzene.

**PHYSICAL PROPERTIES :** pale white or yellow, crystalline solid; soluble in chloroform, ethyl acetate and ethanol; sparingly soluble in benzene; slightly soluble in water; MP (118°C, 244°F); BP (319°C, 606°F); DN (1.565 g/mL at 17°C); SG (1.57 at 20°C); VD (5.79); VP (< 1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible solid; can react vigorously with oxidizing materials; liquid will attack some forms of plastics, rubber, and coatings; shock and friction sensitive; air or oxygen is not required for decomposition; FP (150°C, 302°F); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 3, Flammability 1, Reactivity 4; severe explosion hazard when shocked or exposed to heat or flame; spontaneous decomposition may result from prolonged exposure to fire and heat; mixtures with nitric acid are highly explosive; closed containers may rupture violently when heated; very dangerous; heating to decomposition emits highly toxic fumes of oxides of nitrogen; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cyanosis, dyspnea, irritates eyes, skin and respiratory system); skin absorption (headache, vertigo, nausea, vomiting, rapid weak pulse, decreased blood pressure); ingestion (burning mouth, dry throat, thirst, bad taste, hematuria); contact (yellowing hair, eyes, and skin).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; headache; vertigo; nausea; vomiting; diarrhea; fever; rapid weak pulse; decreased blood pressure; bluish discoloration of skin; exhaustion; numbness of legs; staggering; collapse; yellow jaundice; stains eyes and skin yellow; visual disturbances; burning mouth; dry throat; thirst; bad taste; intense methemoglobinemia leading to asphyxiation; blood in urine.

**CHRONIC HEALTH RISKS:** anemia; liver damage; injury to central nervous system; degeneration of the kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.15 ppm(skin); OSHA PEL TWA 1mg/m<sup>3</sup>(skin); NIOSH REL TWA 1 mg/m<sup>3</sup> (skin); IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear rubber clothing, including rubber gloves, boots, aprons, and hooded suit; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; shovel spilled material into suitable dry containers; large quantities can be dissolved in fuel oil, and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** package dinitrobenzene in paper or other flammable material and burn in suitable combustion chamber equipped with appropriate effluent gas cleaning device; dissolve in fuel oil and atomize in suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from oxidizing materials, metals, and reducing agents; outside storage must be used.

**REGULATORY INFORMATION:** Sf1; Sf3; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of dyestuffs, dyestuff intermediates explosives, and celluloid production; used in organic synthesis and as a substitute for camphor in cellulose nitrate; also used in bursting charges and to fill artillery shells.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12.

### **META-DINITROBENZENE (C<sub>6</sub>H<sub>4</sub>(NO<sub>2</sub>)<sub>2</sub>, 168.12)**

**CAS/DOT IDENTIFICATION #:** 99-65-0/UN1597

**SYNONYMS:** binitrobenzene; m-dinitrobenzene, 1,3-dinitrobenzene, 2,4-dinitrobenzene, 1,3-dinitrobenzol.

**PHYSICAL PROPERTIES :** pale white or yellow, crystalline solid; soluble in chloroform, ethyl acetate and ethanol; sparingly soluble in benzene; slightly soluble in water; MP (89°C, 192°F); BP (302.8°C, 577°F); DN (1.546 g/mL at 17°C); SG (1.58 at 20°C);VP (<1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible solid; can react vigorously with oxidizing materials; liquid will attack some forms of plastics, rubber and coatings; shock and friction sensitive; air or oxygen is not required for decomposition; FP (150°C, 302°F); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** NFPA rating Health 3, Flammability 1, Reactivity 4; severe explosion hazard; can be detonated by shock or heat under confinement that will permit high pressure build-up; mixtures with nitric acid are highly explosive; mixture with tetranitromethane is highly explosive and very sensitive to sparks; explosive decomposition may occur upon prolonged exposure to fire and heat; heating to decomposition emits highly toxic fumes of oxides of nitrogen; use water spray, dry chemical, foam, or carbon dioxide for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (cyanosis, dyspnea, irritates eyes, skin and respiratory system); skin absorption (headache, vertigo, nausea, vomiting, rapid weak pulse, decreased blood pressure); ingestion (burning mouth, dry throat, thirst, bad taste, hematuria); contact (yellowing hair, eyes, and skin).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** oral-human LDLo 28mg/kg; skin-man TDLo 4mg/kg/2D; toxic effect: central nervous system, pulmonary effects.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; headache; vertigo; nausea; vomiting; diarrhea; fever; rapid weak pulse; decreased blood pressure; bluish discoloration of skin; exhaustion; numbness of legs; staggering; collapse; yellow jaundice; stains eyes and skin yellow; visual disturbances; burning mouth; dry throat; thirst; bad taste; intense methemoglobinemia leading to asphyxiation; blood in urine.

**CHRONIC HEALTH RISKS:** anemia; liver damage; injury to central nervous system; degeneration of the kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.15 ppm(skin); OSHA PEL TWA 1mg/m<sup>3</sup>(skin); NIOSH REL TWA 1 mg/m<sup>3</sup> (skin); IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear rubber clothing, including rubber gloves, boots, aprons, and hooded suit; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; shovel spilled material into suitable dry containers; large quantities can be dissolved in fuel oil, and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** package dinitrobenzene in paper or other flammable material and burn in suitable combustion chamber equipped with appropriate effluent gas cleaning device; dissolve in fuel oil and atomize in suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from oxidizing materials, metals, and reducing agents; outside storage must be used.

**REGULATORY INFORMATION:** R3; R5; Sf1; Sf3; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of dyestuffs, dyestuff intermediates, explosives, and celluloid production; used in organic synthesis and as a substitute for camphor in cellulose nitrate; also used in bursting charges and to fill artillery shells.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12.

### **PARA-DINITROBENZENE (C<sub>6</sub>H<sub>4</sub>(NO<sub>2</sub>)<sub>2</sub>, 168.12)**

**CAS/DOT IDENTIFICATION #:** 100-25-4/UN1597

**SYNONYMS:** p-dinitrobenzene, 1,4-dinitrobenzene, dithane A-4.

**PHYSICAL PROPERTIES :** pale white or yellow, crystalline solid; soluble in chloroform, ethyl acetate and ethanol; sparingly soluble in benzene; slightly soluble in water; MP (172-173°C, 342-342°F); (299°C, 570°F); DN (1.6g/mL at 17°C); SG (1.63 at 20°C); VP (<1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible solid; can react vigorously with oxidizing materials; liquid will attack some forms of plastics, rubber, and coatings; shock and friction sensitive; air or oxygen is not required for decomposition; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 3, Flammability 1, Reactivity 4; severe explosion hazard; can be detonated by shock or heat under confinement that will permit high pressure build-up; very volatile with steam; mixtures with nitric acid are highly explosive; prolonged exposure to fire and heat may result in an explosion due to spontaneous decomposition; incompatible with metals, such as tin and zinc; heating to decomposition emits highly toxic fumes of oxides of nitrogen; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cyanosis, dyspnea, irritates eyes, skin and respiratory system); skin absorption (headache, vertigo, nausea, vomiting, rapid weak pulse, decreased blood pressure); ingestion (burning mouth, dry throat, thirst, bad taste, hematuria); contact (yellowing hair, eyes, and skin).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; headache; vertigo; nausea; vomiting; diarrhea; fever; rapid weak pulse; decreased blood pressure; bluish discoloration of skin; exhaustion; numbness of legs; staggering; collapse; yellow jaundice; stains eyes and skin yellow; visual disturbances; burning mouth; dry throat; thirst; bad taste; intense methemoglobinemia leading to asphyxiation; blood in urine.

**CHRONIC HEALTH RISKS:** anemia; liver damage; injury to central nervous system; degeneration of the kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.15 ppm(skin); OSHA PEL TWA 1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 1 mg/m<sup>3</sup> (skin); IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear rubber clothing, including rubber gloves, boots, aprons, and hooded suit; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; shovel spilled material into suitable dry containers; large quantities can be dissolved in fuel oil, and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** package dinitrobenzene in paper or other flammable material and burn in suitable combustion chamber equipped with appropriate effluent gas cleaning device; dissolve in fuel oil and atomize in suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from oxidizing materials, metals, and reducing agents; outside storage must be used.

**REGULATORY INFORMATION:** Sf1; Sf3; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of dyestuffs, dyestuff intermediates, explosives, and celluloid production; used in organic synthesis and as a substitute for camphor in cellulose nitrate; also used in bursting charges and to fill artillery shells.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12.

### **DINITRO-*o*-CRESOL (CH<sub>3</sub>C<sub>6</sub>H<sub>2</sub>OH(NO<sub>2</sub>)<sub>2</sub>, 198.15)**

**CAS/DOT IDENTIFICATION #:** 534-52-1/1598

**SYNONYMS:** 4,6-dinitro-*o*-cresol, 3,5-dinitro-2-hydroxytoluene, 2,4-dinitro-6-methylphenol, DNC, DNOC.

**PHYSICAL PROPERTIES :** yellow, prismatic crystals, sodium salt is a red powder; odorless solid; readily soluble in alkaline aqueous solutions, in ether, acetone, and alcohol; sparingly soluble in water; ammonium, potassium, and calcium salts are soluble in water; MP (87.5°C, 189.5°F); BP (312°C, 594°F); SG (1.1); VD (6.82); VP (0.00005 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable during transport; will not polymerize; reacts vigorously with strong oxidizers; AT (435°C, 815°F); HC (-3920 cal/g); HD (-1.17 kcal/g).

**EXPLOSION and FIRE CONCERNS:** may be explosive when exposed to heat or flame; NFPA rating (not rated); moderately volatile with steam; incompatible with strong oxidizers; combustion products include carbon dioxide, carbon monoxide, and oxides of nitrogen; use water, carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin, shortness of breath); skin absorption (headache, nausea, profuse sweating); ingestion (excessive thirst).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCl<sub>o</sub> 1mg/m<sup>3</sup>; toxic effects: cardiovascular, gastrointestinal tract; oral-man TDLo 7500 µg/kg/7D; toxic effect: central nervous system; unreported-man LDLo 29mg/kg.

**ACUTE HEALTH RISKS:** sense of well being; headache; fever; lassitude; excessive thirst; profuse sweating; coughing; shortness of breath; tachycardia; hyperpnea; nausea; appetite loss; deep, rapid respiration; damage to liver and kidneys; malaise; damage to nervous system; eye and skin irritation; yellow coloring of nails, hands, and hair; greenish-yellow pigmentation of the conjunctiva; coma; death.

**CHRONIC HEALTH RISKS:** cardiovascular effects; gastrointestinal and central nervous system effects; changes in blood count; kidney damage; decreased liver enzyme activity; hyperglycemia; formation of cataracts; blindness; changes in absolute and relative organ weights; weakness; exhaustion; chest pain; breathing difficulty; restlessness; anxiety; unusual thirst; jaundice; coma.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.3 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.2 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.2 mg/m<sup>3</sup>; IDLH 5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear protective clothing and chemical resistant gloves; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** liquid formulations may be reduced to solid phase by evaporation; remove solids by vacuum cleaning or by dissolving them in water or other solvent; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** disposal by high-temperature incineration with scrubbing equipment; package in epoxy-lined drums; keep away from oxidizing materials; store away from heat and flame.

**REGULATORY INFORMATION:** R3; R4; R5; Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf3; CW4; CW5; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in industry as a selective herbicide and insecticide; used in the dyestuff industry; used as a free-radical polymerization inhibitor.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 12; 13; 14.

**DINITROTOLUENE (C<sub>6</sub>H<sub>3</sub>CH<sub>3</sub> (NO<sub>2</sub>)<sub>2</sub>, 182.15)**

**CAS/DOT IDENTIFICATION #:** 25321-14-6/UN2038

**SYNONYMS:** dinitrophenylmethane, dinitrotoluol, dnt, methylidinitrobenzene.

**PHYSICAL PROPERTIES :** yellow, crystalline solid; viscous, oily liquid in molten state; characteristic odor; very slightly soluble in water; soluble in alcohol and ether; MP(70°C, 158°F); BP(300°C, 572°F); DN(1.3208 g/mL liquid at 20°C); LSG (1.32); VD (6.28); REL DN vapor/air mixture (1.01 at 20°C); VP(1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with strong oxidizers, caustics and metals such as tin and zinc; attacks some forms of plastics, rubber, and coatings; commercial grades will decompose at 482°F (250°C), with self-sustaining decomposition at 536°F (280°C); FP (206.7°C, 404.8°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible solid, but difficult to ignite; heating may cause violent combustion or explosion; NFPA rating Health 3, Flammability 1, Reactivity 3; finely dispersed particles may form explosive mixtures in air; violent reaction with strong oxidants, strong bases and metals (such as tin and zinc), causing fire and explosion hazard; decomposes on heating producing carbon monoxide and toxic fumes of oxides of nitrogen; use powder, water spray, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, vomiting, drowsiness, weakness, anoxia); skin absorption (blue lips or fingernails, blue skin, dizziness, headache, weakness); ingestion (blue lips or fingernails, blue skin, headache, dizziness, labored breathing).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if breathing has stopped, provide respiratory support; in case of ingestion, rinse mouth and give large quantities of water to drink; induce vomiting, then get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** anoxia; drowsiness; nausea; vomiting, weakness; cyanosis; dizziness; headache; labored breathing; may cause effects on the blood, resulting in formation of methemoglobin; could cause lowering of consciousness; high concentrations may result in death.

**CHRONIC HEALTH RISKS:** may have effects on the liver, including jaundice; anemia; may impair male fertility; experimental reproductive effects have been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1.5mg/m<sup>3</sup> (skin); OSHA PEL TWA 1.5mg/m<sup>3</sup> (skin); NIOSH REL TWA 1.5mg/m<sup>3</sup> (skin), suspected human carcinogen; IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; use chemical safety goggles or face shield; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use dust explosion-proof electrical equipment and lighting; wear positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** danger area should be evacuated immediately; sweep spilled substance into sealable containers; moisten first to prevent dusting; if in liquid form, absorb with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in sealable containers in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations;

store in a cool, dry location; use only with adequate ventilation; outside storage is preferred; fireproof if in building; separate from strong oxidants, strong bases, metals such as tin and zinc, as well as food and feedstuffs.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf3; CW1; CW2; CW3; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** commercial grades of dinitrotoluene consist of a mixture of six isomers, but mainly 2,4-dinitrotoluene (78%) and 2,6-dinitrotoluene (19%); used in organic synthesis; may also be used in the manufacture of dyes, explosives, and organic chemicals (such as toluidines).

**KEY REFERENCES:** 4; 5; 6; 7; 12; 14.

### DIOXANE (C<sub>4</sub>H<sub>8</sub>O<sub>2</sub>, 88.1)

**CAS/DOT IDENTIFICATION #:** 123-91-1/UN1165

**SYNONYMS:** 1,4-diethylene dioxide, diethylene dioxide (OSHA), diethylene ether, p-dioxane, 1,4-dioxane.

**PHYSICAL PROPERTIES :** colorless liquid; mild, ether-like odor; soluble in ethanol and benzene; soluble in water; forms an azeotrope with water and ethanol; MP(12°C, 53°F); BP (101°C, 214°F); DN (1.0353 g/cm<sup>3</sup> at 20°C); LSG (1.03); ST (32.75 mN/m at 298.15K); VS (0.0120 poise at 25°C); CP (0.0370 kcal/mol/°C at 20°C); HV (38.6 kJ/mol at 25°C); VD (3.03); VP (29 mmHg at 20°C, 40mmHg at 25°C); OT (24 ppm, 86.4 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** reacts vigorously with strong oxidizers, decaborane, and triethynylaluminum; forms peroxides in absence of inhibitors; formation of peroxides may occur in opened containers; FP (12°C, 54°F); LFL/UFL (2.0%, 22.0%); AT (180°C, 356°F); HC (581 kcal/mol); HF (-353.9 kJ/mol liquid at 25°C); H<sub>f</sub> (2.98 kcal/mol).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3; Reactivity 1; dangerous fire hazard when exposed to heat or flame; reacts violently with hydrogen and Raney nickel catalyst; violent reaction with silver perchlorate; forms an explosive reaction with nitric acid and perchloric acid; forms explosive mixtures with decaborane and triethynylaluminum; incompatible with sulfur trioxide; forms explosive peroxides when exposed to air; decomposition emits carbon monoxide and carbon dioxide; vapors are heavier than air and may travel to ignition source and flash back; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (headache, nausea, drowsiness); ingestion (vomiting, liver damage, kidney failure).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** eye-human 300 ppm/15M; inhalation-human TCLo 470ppm; toxic effects: central nervous system, cardiovascular, gastrointestinal tract; inhalation-human TCLo 5500ppm/1M; toxic effects: eye, pulmonary; inhalation-human LCLo 470 ppm/3D; EPA Cancer Risk Level (1 in a million excess lifetime risk) 3 x 10<sup>-6</sup> g/L.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, nose and throat; headache; nausea; vomiting; drowsiness; dizziness; liver damage; kidney failure.

**CHRONIC HEALTH RISKS:** hepatic and renal lesions; may alter genetic material; target organs: liver, kidneys and central nervous system; EPA Group B2: probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm (90mg/m<sup>3</sup>)(skin); OSHA PEL TWA 100 ppm (360mg/m<sup>3</sup>)(skin); NIOSH REL TWA 1 ppm/30M (3.6mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, i.e., chemical-resistant rubber gloves, rubber boots, aprons, etc.; wear splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; cover spill with activated carbon adsorbent; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or activated carbon and place in a sanitary landfill; atomize large amounts in a suitable combustion chamber equipped with afterburner and scrubber; outside storage preferred; inside storage should be in a standard flammable liquids storage room or cabinet.

**REGULATORY INFORMATION:** CA2; R5; R7; U waste # (U108); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf3; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose acetate, ethyl cellulose, benzyl cellulose, resins, oils, waxes, and some dyes; used as a stabilizer in chlorinated solvents.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14.

### DIPHENYL (C<sub>12</sub>H<sub>10</sub>, 154.22)

**CAS/DOT IDENTIFICATION #:** 92-52-4/N/A

**SYNONYMS:** bibenzene, 1,1-biphenyl, phenylbenzene, xenene.

**PHYSICAL PROPERTIES :** white scales; colorless leaflets; pleasant, aromatic odor; soluble in alcohol, ether, and most organic solvent; very soluble in benzene and methanol; practically insoluble in water; MP (69-71°C, 156-160°F); BP (254-255°C, 489-491°F); DN (0.991 g/cm<sup>3</sup> at 75°C); SG (0.992); CP (198.4 J/K-mol at 25°C); VD (5.31); VP (0.005 mmHg at 20°C, 9.46 mmHg at 115°C).

**CHEMICAL PROPERTIES:** combustible solid; will not polymerize; can react with oxidizing materials; FP (113°C, 235°F); LFL/UFL (0.6%, 5.8%); AT (540°C, 1004°F); HF (99.4 kJ/mol at 25°C); H<sub>f</sub>(18.6 kJ/mol at 342K).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating Health 2, Flammability 1, Reactivity 0; reacts vigorously with strong oxidizers; poisonous gases are produced in fire; decomposition emits acrid smoke and toxic fumes; use carbon dioxide, dry chemical water spray, mist, or fog for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); skin absorption (headache, nausea, fatigue, numbness).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human T<sub>CLo</sub> 4400 µg/m<sup>3</sup>; toxic effect: irritant effects.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and throat; irritation to mucous membranes and upper respiratory tract; headache; nausea; fatigue; numb limbs; gastrointestinal disturbances; central nervous system effects; liver damage.

**CHRONIC HEALTH RISKS:** laboratory experiments have shown mutagenic effect; target organs: liver, respiratory system, central nervous system, eyes.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 ppm; OSHA PEL TWA 0.2 ppm (1 mg/m<sup>3</sup>); NIOSH REL TWA 0.2 ppm (1 mg/m<sup>3</sup>); IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear approved respiratory, chemical-resistant gloves, safety goggles, and other protective clothing.

**SPILL CLEAN-UP:** ventilate area of spill; collect powdered material in a safe manner and deposit in sealed containers; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** contain and dispose of biphenyl as a hazardous waste; specific recommendations can be provided by state environmental programs.

**REGULATORY INFORMATION:** CA2; F2; Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf3; T799-18; CAL.

**OTHER COMMENTS:** used as a heat transfer agent; used as a fungistat for oranges (applied to inside of shipping container); used in organic synthesis; used as an intermediate for polychlorinated biphenyls and in the manufacture of benzindine.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 12; 13.

## **DIPROPYLENE GLYCOL METHY ETHER (C<sub>7</sub>H<sub>16</sub>O<sub>3</sub>, 148.23)**

**CAS/DOT IDENTIFICATION #:** 34590-94-8/none

**SYNONYMS:** dipropylene glycol monomethyl ether, dowanol<sup>®</sup>-50B, dpyme, (2-methoxymethylethoxy)-propanol.

**PHYSICAL PROPERTIES:** colorless liquid; mild ether-like color; completely miscible with water, benzene, acetone, ethanol, methanol, carbon tetrachloride, ether, petroleum ether, monochlorobenzene, and Varnish Makers and Painters (VM&P) naphtha; MP(-80°C, -112°F); BP(190°C, 374°F at 760 mmHg); DN(0.948 g/mL at 25°C); LSG(0.95); VS(3.5 cP at 25°C); VD(5.11); REL DN vapor/air mixture (1.0 at 20°C); VP(0.41 mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react with strong oxidizing materials; FP(74°C, 165°F); LFL/UFL (1.3%, 10.4%); AT (270°C, 518°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 0, Flammability 2, Reactivity 0; explosive vapor/air mixtures may be formed above 74°C; can be presumed to form explosive peroxides upon contact with air; reacts violently with strong oxidants, causing fire and explosion; heating to decomposition emits carbon dioxide and carbon monoxide; use dry chemical, alcohol-resistant foam, water spray, or carbon dioxide for fire-fighting purposes.

## 592 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, and throat); skin absorption (headache, weakness, lightheadedness).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of water; if breathing is difficult, give oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, rinse mouth and then give water to drink.

**HUMAN TOXICITY DATA:** eye-human 8 mg mild irritant effects.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and throat; headache; lightheadedness; weakness; dry skin.

**CHRONIC HEALTH RISKS:** mild allergen; no other information found.

**EXPOSURE GUIDELINES:** ACGIH TLV 100 ppm (606 mg/m<sup>3</sup>) (skin); OSHA PEL TWA 100 ppm (600 mg/m<sup>3</sup>) (skin); NIOSH REL TWA 100 ppm (600 mg/m<sup>3</sup>); NIOSH REL STEL 150 ppm (900 mg/m<sup>3</sup>) (skin); IDLH (600 ppm).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; above 74°C, enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** collect leaking liquid in sealable containers or absorb with noncombustible materials (e.g., dry earth, sand, vermiculite); wash away remainder with plenty of water.

**DISPOSAL AND STORAGE METHODS:** collect leaking liquid in sealable containers or absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry location; maintain adequate ventilation along the floor; separate from oxidants.

**REGULATORY INFORMATION:** T120-a; A1; CAL; DOT classification (not found in literature).

**OTHER COMMENTS:** there are four known structural isomers of dipropylene glycol monomethyl ether; used as a solvent for automotive fluids, dyes, cleaners, adhesives, coatings, inks, waxes, insect repellants, cosmetics, and agricultural products; useful as a chemical intermediate.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### DI-SEC OCTYL PHTHALATE (C<sub>24</sub>H<sub>38</sub>O<sub>4</sub>, 390.62)

**CAS/DOT IDENTIFICATION #:** 117-81-7/NA

**SYNONYMS:** bis(2-ethyl)phthalate, DEHP, di(2-ethylhexyl)phthalate, DOP, octyl phthalate.

**PHYSICAL PROPERTIES :** colorless, oily liquid, slight odor; negligible solubility in water; MP (-50°C, -58°F); BP (386°C, 727°F); DN (0.986 g/mL at 20°C); LSG (0.99); VS (80 cP at 20°C); VP (6.2 x 10<sup>-8</sup> mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable under normal temperature and pressure; reacts with nitrates, strong oxidizers, acids, and alkalies; FP (199°C, 390°F); LFL/UFL (0.3%, NA); AT (390°C, 734°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; incompatible with strong oxidants; irritating and toxic gases are emitted during a fire; decomposition products include carbon dioxide and carbon monoxide; when heated to decomposition, emits toxic gases and acrid smoke; use dry chemical, alcohol-resistant foam, water spray or mist for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates skin and eyes); ingestion (gastrointestinal effects).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin immediately with large amounts of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-man TDLo 143 mg/kg; toxic effect: gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and mucous membranes; liver and kidney effects; adverse effects on weight gain and food consumption.

**CHRONIC HEALTH RISKS:** no information is available on the chronic effects in humans; EPA Group B2: probably human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg/m<sup>3</sup>; STEL 10 mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; STEL 10 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; STEL 10 mg/m<sup>3</sup>; IDLH 5000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and chemical resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb liquid with non-combustible materials (e.g., dry earth, sand or vermiculite), and place in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; separate from incompatibles; avoid heat, sparks, and open flame.

**REGULATORY INFORMATION:** S24; S32; S50-a; S61; S62; Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf3; T799-5000; CAL.

**OTHER COMMENTS:** used as a plasticizer in flexible vinyl products; used as replacement for PCBs in dielectric fluids for electric capacitors.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 12; 13; 14.

## **EMERY (Al<sub>2</sub>O<sub>3</sub>, 101.96)**

**CAS/DOT IDENTIFICATION #:** 12415-34-8/none

**SYNONYMS:** aluminum oxide, aluminum trioxide, corundum, impure corundum, natural aluminum oxide.

**PHYSICAL PROPERTIES:** mixture of aluminum oxide ( $\text{Al}_2\text{O}_3$ ) and magnetite, with or without hematite; varies in hardness according to iron oxide present; solid medium brown color (corundum) or white crystalline powder (emery); odorless; insoluble in water; MP (2072°C, 3761.6°F); BP (2980°C, 5396°F); DN/SG (4.0); CP (79.0 J/K-mol crystal at 25°C)(corundum); VD (NA); VP (approximately 0 mmHg at 20°C, 0.750 mmHg at 2158°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; very resistant to attack by acids; finely divided iron will emit hydrogen gas upon exposure to moisture during crushing and milling operations; hazardous decomposition products have not been reported; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-1675.7 kJ/mol crystal at 25°C)(corundum).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; dusts may form explosive mixtures in air; incompatible with chlorine trifluoride, hot chlorinated rubber and strong oxidizers; in case of fire in the surroundings, use water spray, dry chemical, foam or carbon dioxide for firefighting purposes; water may be ineffective but should be used to keep drums cool.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory tract); contact (may cause pneumoconiosis, may cause skin abrasions).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; flush affected areas of skin with large amounts of soap and water; if breathing is difficult, provide oxygen; provide artificial respiration if breathing has stopped; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no  $\text{LD}_{50}/\text{LC}_{50}$  information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; irritation to tissues of mucous membranes; may cause a pneumoconiosis.

**CHRONIC HEALTH RISKS:** excessive exposure may cause pulmonary fibrosis; targets eyes, skin, lungs, and respiratory tract.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $10 \text{ mg}/\text{m}^3$  (for particulate matter containing no asbestos and <1% crystalline silica); OSHA PEL TWA  $15 \text{ mg}/\text{m}^3$  (total dust);  $5 \text{ mg}/\text{m}^3$  (respirable fraction); NIOSH REL TWA (no established REL); IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron, sleeves, or body-covering coveralls; wear dust-proof safety goggles; enclose operations and use local exhaust ventilation to keep airborne concentration below limits; utilize approved respiratory protection for nuisance dust; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** sweep spilled substance into containers; sweep gently to avoid raising dust or use handling methods, such as wet vacuuming, to minimize dust dispersal; wash away remainder with plenty of water.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; store in a cool, dry location in secured, sealable containers; keep in a well-ventilated room.

**REGULATORY INFORMATION:** CAL; DOT hazard class/division (none); label (none required).

**OTHER COMMENTS:** Emery is an impure variety of aluminum oxide ( $\text{Al}_2\text{O}_3$ ), sometimes with small amounts of iron, magnesium, and silica. Corundum is natural aluminum oxide ( $\text{Al}_2\text{O}_3$ ), which is a different and hard crystalline form of aluminum oxide. This material may be used in various polishing and abrasive operations; may also be utilized during grinding and milling operations.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

**ENDOSULFAN ( $\text{C}_9\text{H}_6\text{Cl}_6\text{O}_3\text{S}$ , 406.91)**

**CAS/DOT IDENTIFICATION #:** 115-29-7/UN2761

**SYNONYMS:** benzoepin, endosulphan, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide, (1,4,5,6,7,7-hexachloro-8,9,10-trinorborn-5-en-2,3-ylenedimethyl) sulfite, thiosulfan.

**PHYSICAL PROPERTIES :** brown crystals; technical product is a tan, waxy mixture of two isomers; slight, sulfur dioxide odor; soluble in most organic solvents; nearly insoluble in water; MP (70-100°C, 158-212°F; 106°C, 223°F (pure); 108-110°C, 226-230°F ( $\alpha$ -isomer) and 208-210°C, 406-410°F ( $\beta$ -isomer)); BP (decomposes); DN (1.745 g/cm<sup>3</sup> at 20°C); SG (1.75); VP (not applicable); VP (0.00001 mmHg at 77°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; stable toward dilute mineral acids; hydrolyzed rapidly by alkalis; hydrolyzes slowly on contact with water; corrosive to iron; decomposes in presence of alkalis and acids to form sulfur dioxide; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; liquid formulations containing organic solvents may be flammable; explosion hazard will depend on formulation solvent or on characteristics of the dust; reacts with bases causing toxic fumes of sulfur dioxide; decomposes on heating emitting toxic and corrosive fumes of hydrogen chloride and oxides of sulfur; use all extinguishing agents for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, blue lips or fingernails, nausea, vomiting, diarrhea, weakness, loss of consciousness, convulsions, irritability); skin absorption (confusion, agitation, flushing of skin, tremors); ingestion (nausea, vomiting, diarrhea, dry mouth).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and then wash skin with soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if swallowed, induce vomiting and get immediate medical attention..

**HUMAN TOXICITY DATA:** oral-man TDLo 86 mg/kg; toxic effect: behavioral effects, pulmonary system; sister-chromatid exchange-human lymphocyte 1  $\mu\text{mol/L}$ .

**ACUTE HEALTH RISKS:** irritation of skin; headache; dizziness; blue lips or fingernails; nausea; vomiting; diarrhea; dry mouth; tremor; irritability; convulsions; confusion; flushing; unconsciousness; death due to exposure at high levels.

**CHRONIC HEALTH RISKS:** injury to the kidney and liver has been reported in humans; may possibly alter genetic materials and cause reproductive effects; targets skin, central nervous system, liver, kidneys, and reproductive system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg/m<sup>3</sup>(skin); OSHA PEL TWA (none); NIOSH REL TWA 0.1 mg/m<sup>3</sup>(skin); IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use face shield or eye protection in combination with breathing protection; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** collect leaking liquid in sealable containers; sweep spilled substance into sealable containers; flush remainder with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be managed for recovery or recycling should be managed in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry area; maintain adequate ventilation; separate from strong bases, acids, food and feedstuffs; isolate from ferrous material.

**REGULATORY INFORMATION:** F2; F4; F7; R4; R6; R8; P waste # (P050); Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; Sf2; CW1; CW2; A1; CAL.

**OTHER COMMENTS:** substance is a mixture of alpha isomer (melting point: 108-110°C) and beta isomer (melting point: 208-210°C); carrier solvents used in commercial formulations may change physical and toxicological properties; high toxic organochlorine pesticide that does not accumulate significantly in human tissue; absorption is usually increased by alcohols, oil, and emulsifiers.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

### **ENDRIN (C<sub>12</sub>H<sub>8</sub>Cl<sub>6</sub>O, 380.90)**

**CAS/DOT IDENTIFICATION #:** 72-20-8/UN2761

**SYNONYMS:** 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethanonaphthalene; hexadrin<sup>®</sup>; mendrin<sup>®</sup>; nendrin<sup>®</sup>.

**PHYSICAL PROPERTIES :** colorless to tan, crystalline solid; mild, chemical odor; soluble in acetone, benzene, and xylene; slightly soluble in carbon tetrachloride and hexane; insoluble in water and methanol; MP (>226°C, >439°F); BP (decomposes); SG (1.70 at 20°C); VP (2 x 10<sup>-7</sup> mmHg at 25°C).

**CHEMICAL PROPERTIES:** generally very stable; hazardous polymerization will not occur; reacts vigorously with strong acids and strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HF (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid, but may be dissolved in flammable liquids; NFPA rating (NA); dangerous fire hazard; mixtures with parathion dissolve very exothermically in petroleum solvents and may cause an air-vapor explosion; incompatible with strong acids, strong oxidizing agents, and parathion; may emit hydrogen chloride and phosgene when heated or burned; use carbon dioxide, dry chemical powder, or water spray for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, convulsions, stupor); skin absorption (aggressiveness, confusion, weakness, lethargy, insomnia); ingestion (abdominal discomfort, nausea, vomiting, anorexia); contact (irritates, eyes, damage to eyes).

**FIRST AID:** flush eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if breathing has stopped, administer artificial respiration and get immediate medical assistance; if swallowed, induce vomiting.

**HUMAN TOXICITY DATA:** oral-man LDLo 171mg/kg.

**ACUTE HEALTH RISKS:** injury to central nervous system; eye irritation; gastrointestinal disturbances; abdominal discomfort.

**CHRONIC HEALTH RISKS:** nausea; headache; dizziness; eye damage; disorientation; aggressiveness; lethargy; weakness; anorexia; epileptiform convulsions; may cause liver damage and possible reproductive effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.1 mg/m<sup>3</sup>(skin); IDLH 2mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use approved chemical safety goggles; wear a supplied air, full face-piece respirator or self-contained breathing apparatus; emergency eyewash fountains and shower facilities should be provided in immediate work area.

**SPILL CLEAN-UP:** evacuate area; ventilate area of spill or leak; sweep up and place in an appropriate container; wash contaminated surfaces to remove any residues.

**DISPOSAL AND STORAGE METHODS:** burn in a chemical incinerator equipped with an afterburner and scrubber; dispose of in accordance with local, state and federal regulations; store in a cool, dry place with plenty of ventilation; keep containers tightly closed; store only with compatible chemicals.

**REGULATORY INFORMATION:** S24, S32-66; S50-b26; S61-c26; S62'-45; F1; R1; R3; R4; R5; R6; R8; D waste # (D012); P waste #(P051); Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; Sf2; CW1; CW2; CW4; CW5; T102; T799-5055; A1; CAL; DOT hazard class/division (none)

**OTHER COMMENTS:** formerly used as an insecticide; product is furnished for laboratory use only; manufacture and use has been discontinued in the United States.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

### **EPICHLOROHYDRIN (C<sub>3</sub>H<sub>5</sub>OCl, 92.53)**

**CAS/DOT IDENTIFICATION #:** 106-89-8/UN2023

**SYNONYMS:** 1-chloro-2,3-epoxypropane, 3-chloro-1,2-epoxypropane, 3-chloro-1,2-propylene oxide, 2,3-epoxypropyl chloride, gamma-chloropropylene oxide.

**PHYSICAL PROPERTIES :** colorless liquid; irritating, chloroform-like odor; miscible with alcohol, ether, chloroform, trichloroethylene, and carbon tetrachloride; immiscible with petroleum hydrocarbons; insoluble in water; MP (-48°C, -54°F); BP (116°C, 241°F); DN (1.1812 g/cm<sup>3</sup> at 20°C); LSG (1.18); VS (1.073 mPa-s at 25°C); ST (36.36 mN/m at 25°C);

CP (131.6 J/K-mol liquid at 25°C); HV (37.91 kJ/mol at 389K); VD (3.29); VP (13 mmHg at 20°C).

**CHEMICAL PROPERTIES:** hazardous polymerization may occur; may polymerize in presence of strong acids and bases, particularly when hot; reacts with strong oxidizers, strong acids, metallic salts, caustics, zinc, aluminum, and water; FP (31°C, 88°F); LFL/UFL (3.8%, 21%); AT (411°C, 772°F); HC (-4524 cal/g); HF (-148.4 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 3, Flammability 3, Reactivity 2; reacts violently with sulfuric acid or isopropylamine; explosive reaction with aniline; reacts explosively with trichloroethylene to form dichloroacetylene; ignites on contact with potassium tert-butoxide; polymerizes exothermically on contact with strong acids, strong bases, aluminum, aluminum chloride, iron (III) chloride, or zinc; vapors may flow along surfaces to distant ignition sources and flash back; closed containers exposed to heat may rupture and explode; combustion by-products include hydrogen chloride, carbon monoxide, carbon dioxide, and phosgene gas; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (inflammation of the lungs, asthmatic bronchitis); contact (severe irritation or burns); ingestion (nausea, vomiting, headache, convulsions, unconsciousness).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human T<sub>CLo</sub> 40ppm/2H; toxic effect: pulmonary; inhalation-human T<sub>CLo</sub> 20ppm; toxic effect: eye; sce-human lymphocyte 10nmol/L; dni-human hla 2700µmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes or skin with deep pain; nausea; vomiting; abdominal pain; respiratory distress; coughing; unconsciousness; convulsion; inflammation of the lungs; asthmatic bronchitis; cyanosis; central nervous system depression; reproductive effects.

**CHRONIC HEALTH RISKS:** experiments conducted in the laboratory have shown mutagenic effects; target organs: liver, kidneys, eyes, skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (skin); OSHA PEL TWA 5 ppm (19mg/m<sup>3</sup>)(skin); NIOSH REL minimize exposure; IDLH 75 ppm.

**PERSONAL PROTECTION:** wear special protective suit; rubber gloves are recommended; wear chemical safety goggles and face shield; wear appropriate respirators and self-contained breathing apparatus at concentrations above 2 ppm.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; use appropriate foam to blanket release and suppress vapors; clay absorbents are not recommended in cleanup; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible in noncombustible materials and place in a sanitary landfill; store in a cool, dry, well-ventilated area; storage should be in tightly sealed containers, away from heat, oxidizing materials, and sunlight; outside storage is preferred.

**REGULATORY INFORMATION:** CA2; S1; S32; S50-a; R4; R7; R8; U waste # (U041); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf2; Sf3; CW1; CW2; A1; CAL; DOT hazard class/division (6.1); labels (poisonous material).

**OTHER COMMENTS:** used as a solvent for natural and synthetic resins, gums, paints, varnishes, nail enamels, and lacquers; used in pharmaceuticals and agricultural chemicals; also used as a stabilizer in chlorine-containing materials.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 10; 12; 14.

**EPN (C<sub>14</sub>H<sub>14</sub>NO<sub>4</sub>PS, 323.32)**

**CAS/DOT IDENTIFICATION #:** 2104-64-5/UN2783

**SYNONYMS:** ethyl-p-nitrophenyl benzenethionophosphonate, ethyl-p-nitrophenyl phenylphosphonothioate, O-ethyl-O(4-nitrophenyl)phenylphosphonothioate.

**PHYSICAL PROPERTIES :** liquid or pale-yellow crystals; a brown liquid above 97°F; aromatic odor; nearly insoluble in water; miscible with benzene, toluene, xylene, acetone, isopropanol, and methanol; MP (36°C, 97°F); BP (unknown); DN (1.268 g/mL at 25°C); LSG (1.27 at 25°C); VD (not applicable); VP (0.0003 mmHg at 212°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react vigorously with strong oxidizers; decomposes under influence of alkalis (hydrolysis); FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; explosion hazard will depend on the solvent used in the formulation or on the characteristics of the dust; gives off irritating or toxic fumes in a fire; decomposes on heating and on burning producing toxic and corrosive fumes of oxides of nitrogen, phosphorus, and sulfur; use alcohol foam, dry powder or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, labored breathing, constriction of pupils, muscle cramps, excessive salivation, nausea, vomiting, convulsions, unconsciousness); skin absorption (symptoms parallel those of inhalation); ingestion (abdominal cramps, nausea, vomiting, diarrhea, labored breathing, excessive salivation, muscle cramps, loss of consciousness).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and then wash skin with soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if case of ingestion, induce vomiting and get immediate medical attention..

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** headache; tight chest; labored breathing; dizziness; lacrimation; pupillary constriction; rhinorrhea; muscle cramps; excessive salivation; wheezing; laryngeal spasm; cyanosis; convulsions; nausea; vomiting; diarrhea; abdominal cramps; respiratory failure; exposure at high level may result in death.

**CHRONIC HEALTH RISKS:** cholinesterase inhibitor; anorexia; low blood pressure; cardiac irregularities; paralysis; cumulative effects of acute hazards/symptoms is possible.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.5 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup>(skin); IDLH 5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection if powder; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use self-contained breathing appa-

ratus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into containers; moisten first to prevent dusting; flush remainder with large amounts of water but not into spaces such as sewers because of danger of explosion.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; separate from strong oxidizing materials, food and feed-stuffs.

**REGULATORY INFORMATION:** F1.

**OTHER COMMENTS:** used for cotton insect pest control; useful as an acaricide; substance may be hazardous to the environment; special attention should be given to bees and fish.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### **ETHANOLAMINE (NH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>OH, 61.10)**

**CAS/DOT IDENTIFICATION #:** 141-43-5/UN2491

**SYNONYMS:** 2-aminoethanol,  $\beta$ -aminoethyl alcohol, colamine, ethylolamine, 2-hydroxyethylamine, monoethanolamine.

**PHYSICAL PROPERTIES :** clear to yellowish viscous liquid; hygroscopic; solid below 51°F; unpleasant, ammonia-like odor; miscible with water, methanol, and acetone; soluble in chloroform; slightly soluble in benzene; absorbs carbon dioxide; MP (10°C, 51°F); BP (171°C, 339°F); DN (1.012 g/mL at 25°C); LSG (1.01); ST (48.32 mN/m at 25°C); VS (18.95 cP at 25°C, 5.03 cP at 60°C); HV (49.83 kJ/mol at 444.1K); VD (2.1); VP (6 mmHg at 60°C).

**CHEMICAL PROPERTIES:** combustible liquid; strong alkali; may attack copper, brass, and rubber; reacts with strong oxidizers, strong acids and halogenated hydrocarbons to produce heat; FP (93.3°C, 200°F); LFL/UFL (3%, 23.5% at 284°F); AT (410°C, 770°F); HC (NA); HF (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 3, Flammability 2, Reactivity 0; flammable when exposed to heat or flame; reacts violently with acetic acid, acetic anhydride, acrylic acid, acrolein, acrylonitrile, chlorosulfonic acid, cellulose, epichlorohydrin, hydrogen chloride, hydrogen fluoride, nitric acid, sulfuric acid, mesityl oxide, oleum,  $\beta$ -propiolactone, and vinyl acetate; reaction with iron produces an unstable and pyrophoric complex triethanolaminoiron; very powerful base; heating to decomposition emits toxic fumes of oxides and nitrogen; use water spray, dry chemical, foam, or carbon dioxide for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); ingestion (nausea, vomiting, lethargy, severe burns to the mouth and stomach); contact (dermatitis, severe eye and skin burns).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** cytogenetic analysis-human lymphocyte 100 $\mu$ mol/L; sister chromatid exchange-human lymphocyte 1mmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; irritation to tissues of mucous membranes; severe eye and skin burns; coughing; difficult breathing; pulmonary edema; irritation of mouth and stomach; nausea; vomiting; headache; convulsions; loss of consciousness.

**CHRONIC HEALTH RISKS:** lethargy; dermatitis; visual disturbances; target organs: eyes, skin, respiratory system, central nervous system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 3 ppm; ACGIH TLV STEL 6 ppm; OSHA PEL TWA 3 ppm (6mg/m<sup>3</sup>); NIOSH REL TWA 3 ppm (8 mg/m<sup>3</sup>); NIOSH REL STEL 6 ppm (15 mg/m<sup>3</sup>); IDLH 30 ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear self-contained breathing apparatus in high vapor concentrations; wear boots, gloves, aprons, etc.; wear splash-proof safety goggles.

**SPILL CLEAN-UP:** absorb as much as possible in noncombustible materials such as dry earth, sand, or vermiculite; flush remaining ethanalamine with large amounts of water and dilute to form nonflammable mixtures.

**DISPOSAL AND STORAGE METHODS:** add contaminated amine to layer of sodium bisulfate, spray with water, neutralize, and route to sewage plant; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; separate from oxidizing materials, acids, and halogens.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used in scrubbing acid gases, such as hydrogen sulfide and carbon dioxide, from natural gas and other gases; used in the manufacture of nonionic detergents used in dry cleaning; also used in polishes, emulsion paints, hair waving solutions, and as a dispersing agent for agricultural chemicals; is reacted with other substances to form an accelerator in the preparation of antibiotics.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 14.

## 2-ETHOXYETHANOL (C<sub>2</sub>H<sub>5</sub>OCH<sub>2</sub>CH<sub>2</sub>OH, 90.14)

**CAS/DOT IDENTIFICATION #:** 110-80-5/UN1171

**SYNONYMS:** cellosolve<sup>®</sup>, ethyl cellosolve, ethylene glycol monoethyl ether, glycol ethyl ether, monoethyl glycol ether, oxitol.

**PHYSICAL PROPERTIES :** clear, colorless, viscous liquid; pleasant, ether-like odor; miscible with water, ethanol, diethyl ether, acetone, and liquid esters; dissolves many oils, waxes, resins, etc.; MP (-70°C, -94°F); BP (135°C, 275°F); DN (0.9311 g/mL at 20°C); LSG (0.93); ST (28.35 mN/m at 25°C); HV (48.21 kJ/mol at 25°C); VD (3.10); REL DN vapor/air mixture (1.00 at 20°C); VP (3.8 mmHg at 20°C); PP (<37.7°C, <100°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; excessive temperatures or prolonged reflux, such as in batch distillations, will lead to instability;

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should not be distilled to dryness; reported to dissolve aluminum surfaces; attacks many plastics and rubber; can react with oxidizing materials; FP (43°C, 109°F); LFL/UFL (1.7%, 15.7%); AT (235°C, 455°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; NFPA rating Health 2, Flammability 2, Reactivity 0; formation of explosive peroxides has been reported from auto-oxidation; sealed containers may rupture when heated; flashback along vapor trail may occur; sensitive to static discharge; may produce a floating fire hazard in extreme fire conditions; reacts with strong oxidizers causing fire and explosion hazard; mixture with hydrogen peroxide and polyacrylamide gel and toluene is explosive when dry; incompatible with strong oxidizers, strong acids, strong bases, copper and aluminum; decomposes on burning, producing toxic gases (carbon monoxide and carbon dioxide); use powder, alcohol foam, water spray or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sore throat, coughing, shortness of breath, headache, drowsiness, nausea, weaknesses, irritates respiratory tract); skin absorption (narcotic effects, drowsiness, weakness, loss of consciousness); skin contact (redness, pain, defatting of skin); eye contact (blurred vision, tearing, stinging, swelling, severe pain); ingestion (abdominal pain, nausea, vomiting, breathing difficulties, liver damage, injury to kidneys, blood changes).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if ingested, rinse mouth and induce vomiting; call a physician immediately.

**HUMAN TOXICITY DATA:** eye-human 6000 ppm; this compound has caused birth defects in laboratory animals, as well as damage to the reproductive system; has also cause decreased sperm counts in humans; investigated as tumorigen, mutagen, and reproductive effector.

**ACUTE HEALTH RISKS:** irritation to the respiratory tract; sore throat; coughing; shortness of breath; headache; drowsiness; weakness; narcosis; abdominal pain; nausea; vomiting; central nervous system depression; liver damage; kidney damage; severe eye pain, including tearing, swelling and stinging; may result in unconsciousness.

**CHRONIC HEALTH RISKS:** may cause injury to bone marrow and blood cells, resulting in anemia and lesions of blood cells; could cause effects on the liver and kidney; suspected human reproductive and birth defect hazard.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (18 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 200 ppm (740 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.5 ppm (1.8 mg/m<sup>3</sup>)(skin); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles or face-shield; above 44°C (111°F), use a closed system of local exhaust ventilation and explosion proof electrical equipment; if the exposure limit is exceeded, wear self-contained breathing apparatus; maintain eye wash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking or spilled liquid in sealable container or absorb with an inert material (e.g., dry earth, sand, vermiculite); wash away remainder with large amounts of water but not into spaces such as sewers because of danger of explosion; use water spray to cool and reduce vapors, and to flush spills away from exposures; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry sand or inert absorbent, and place in a secured, sanitary landfill; dispose of in accordance with federal, state and local regulations; store in a cool, dry location; use only with adequate ventilation; keep in the dark; outside storage is preferred; protect against physical damage; containers should be bonded and grounded for transfers to avoid static sparks; keep containers tightly closed; separate from strong oxidants; keep away from heat, sparks and flame.

**REGULATORY INFORMATION:** S10; Reportable Quantity (RQ): 1000 lbs. (454 kg); Sf3; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose, lacquers, natural and synthetic resins; other applications include varnish removers, cleaning solutions, dyeing and printing textiles, and leather finishings; used as an anti-icing additive for aviation fuels.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

## 2-ETHOXYETHYL ACETATE (C<sub>6</sub>H<sub>12</sub>O<sub>3</sub>, 132.18)

**CAS/DOT IDENTIFICATION #:** 111-15-9/UN1172

**SYNONYMS:** acetic acid-2-ethoxyethyl ester, cellosolve<sup>®</sup> acetate, 2-ethoxyethanol acetate, ethylene glycol monoethyl ether acetate, glycol monoethyl ether acetate.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mild, pleasant, ester-like odor; objectionable odor at high concentrations; miscible with aromatic hydrocarbons; slightly miscible with water; MP (-61.7°C, -80°F); BP (156°C, 313°F); DN (0.9748 g/mL at 20°C); LSG (0.98 at 20°C); VS (1.32 cP at 20°C); HV (52.69 kJ/mol at 25°C); VD (4.7); RELDN of VAP/AIR MIXTURE (1.01 at 20°C); BP (2 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with strong oxidants, strong bases, strong acids and nitrates; FP (47°C, 117°F); LFL/UFL (1.7%, unknown); AT (379°C, 714°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 2, Reactivity 0; moderate explosion hazard in form of vapor when heated; explosive vapor/air mixtures may be formed above 51.1°C; flashback along vapor trail may occur; mild explosions have occurred at the end of distillations; contact with strong oxidizers may cause fire; sealed containers may rupture when heated; sensitive to static discharge if dry; can be charged electrostatically by swirling, pneumatic transport, pouring, etc.; can presumably form explosive peroxides; incompatible with strong alkalis, acids, nitrates, and oxidizing agents; heating to decomposition emits carbon monoxide and carbon dioxide; use dry chemical, alcohol foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates nose and throat, dizziness, drowsiness, headache, unconsciousness, weak narcotic effects, damage to kidneys, blood and blood-forming organs); skin contact (redness, itching, pain); eye contact (redness, itching, pain); ingestion (nausea, vomiting, diarrhea, systemic poisoning with symptoms paralleling those of inhalation).

**FIRST AID:** rinse eyes with plenty of water for several minutes; wash affected areas of skin with plenty of soap and water; if swallowed, give large quantities of water; do not induce vomiting and get medical attention immediately; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of nose and throat; affects central nervous system; may cause effects on the blood; headache; dizziness; drowsiness; nausea; vomiting; diarrhea; systemic poisoning; irritation to skin, including redness, itching, and pain; irritation of eyes, including redness and pain; loss of consciousness.

**CHRONIC HEALTH RISKS:** can cause damage to kidneys, blood and blood forming organs; possibly causes toxic effects upon human reproduction; can damage the developing fetus; personality changes may occur as a result of central nervous system damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (27 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 100ppm (540mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.5ppm (2.7mg/m<sup>3</sup>)(skin); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; butyl rubber is a suitable material for personal protective equipment; use chemical safety goggles and/or full face shield where splashing is possible; a closed system of local exhaust ventilation is recommended because it can control emissions at its source and prevent dispersion into the general work area; use explosion-proof electrical equipment; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); in high vapor concentrations wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect spilled liquid in sealable containers as far as possible; absorb remaining liquid with an inert material (e.g., dry sand, earth, vermiculite), and place in a chemical waste container; use water spray to reduce vapors and to flush spills away from exposures, but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible in sand or inert absorbent and place in a sanitary landfill; also, whatever cannot be saved for recovery or recycling may be sent to a RCRA approved incinerator or disposed of in a RCRA approved waste facility; store in a cool, dry, well-ventilated location; outside storage is preferred; containers should be bonded and grounded for transfers to avoid static sparks; separate from strong alkalis, acids, nitrates, and oxidizing agents; keep away from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose, oils, and resins; retards evaporation in automobile lacquers and imparts high gloss; useful as a laboratory reagent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

## **ETHYL ACETATE (CH<sub>3</sub>COOC<sub>2</sub>H<sub>5</sub>, 88.12)**

**CAS/DOT IDENTIFICATION #:** 141-78-6/UN1173

**SYNONYMS:** acetic acid ethyl ester, acetic ester, acetic ether, acetoxyethane, ethyl acetic ester, ethyl ester of acetic acid, ethyl ethanoate.

**PHYSICAL PROPERTIES :** colorless liquid; fragrant fruity odor; pleasant taste when diluted; absorbs water (up to 3.3% w/w); forms an azeotropic mixture with water (6.1% w/w) having a boiling point of 70.4°C; also forms an azeotropic mixture with water (7.8% w/w) and

alcohol (9.0% w/w) having a boiling point of 70.3°C; miscible with alcohol, ether, chloroform, acetone, glycerin, volatile oils, and most organic solvents; slightly soluble in water at 25°C; solubility in water increases at lower temperatures and decreases at higher temperatures; MP (-83°C, -117°F); BP (77°C, 171°F); DN (0.8946 g/mL at 25°C); LSG (0.902 at 20°C); ST (23.39 mN/m at 25°C); VS (0.423 mPa-s at 25°C); CP (170.7 J/K-mol liquid at 25°C); HV (10.5 kJ/mol at 189.5K); VD (3.04); VP (76 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; heat will contribute to instability; hazardous polymerization will not occur; will attack some forms of plastic, rubber, and coatings; can react vigorously with oxidizing materials; slowly decomposed by moisture; FP (-4°C, 25°F); LFL/UFL (2.0%, 11.5%); AT (426°C, 799°F); HC (-2.0610 x 10<sup>9</sup> J/kmol); HF (-479.3 kJ/mol liquid at 25°C); H<sub>f</sub> (10.5 kJ/mol at 189.5K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; NFPA rating Health 1, Flammability 3, Reactivity 0; vapor-air mixtures are explosive above flashpoint; sealed containers may rupture when heated; sensitive to static discharge; contact with strong oxidizers may cause fire; potentially explosive reaction with lithium tetrahydroaluminate; reacts violently with chlorosulfonic acid, lithium aluminum hydride and 2-chloromethyl furan, and oleum; ignites on contact with potassium tert-butoxide; flashback along vapor trail may occur; incompatible with nitrates, strong oxidizers, strong alkalies, and strong acids; heating to decomposition emits carbon dioxide and carbon monoxide; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates mucous membranes, conjunctiva irritation, pulmonary changes olfactory changes, coughing, wheezing, shortness of breath, laryngitis, headache, nausea, vomiting, mild narcosis, liver and kidney damage, irritates nose, throat and upper respiratory tract); skin contact (defatting effect, dryness, cracking, dermatitis); eye contact (irritation, redness, pain, corneal clouding); ingestion (nausea, vomiting, diarrhea).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, drink large amounts of water and get medical attention immediately.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 400 ppm; toxic effect: nose, eye, pulmonary system; eye-human 400 ppm.

**ACUTE HEALTH RISKS:** irritation of mucous membranes, particularly eyes, gums and respiratory passages; irritation to upper respiratory tract; coughing ;wheezing; shortness of breath; laryngitis; burning sensation; irritation of nose and throat; nausea; vomiting; diarrhea; skin irritation, including redness, itching, and pain; conjunctival irritation; corneal clouding; narcotic effects; congestion of the liver and kidneys.

**CHRONIC HEALTH RISKS:** anemia; leukocytosis (transient increase in white blood cell count); cloudy swelling and fatty degeneration of the viscera; damage to the liver and kidneys; prolonged contact with skin may cause defatting, dryness, cracking, and possible dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 400 ppm; OSHA PEL TWA 400 ppm (1400 mg/m<sup>3</sup>); NIOSH REL TWA 400 ppm (1400 mg/m<sup>3</sup>); IDLH 200 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles where splashing is possible; a system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; in the event of a fire, wear positive pressure

self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area; use non-sparking tools and equipment.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect liquid in an appropriate container or absorb with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; water may be used to flush remaining spills away from exposures and to dilute spills to form non-flammable mixtures; do not flush into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or other inert material, and place in a sanitary landfill; dispose of container and unused contents in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; outside storage is preferred; containers should be bonded and grounded for transfers to avoid static sparks; storage areas should include explosion proof ventilation; keep away from any area where the fire hazard may be acute; separate from incompatibles.

**REGULATORY INFORMATION:** S10; U waste # (U112); Reportable Quantity (RQ): 5000 lbs. (2270kg); Sf1; T799-5000; A1; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used as a pharmaceutical aid; used as a synthetic flavoring substance; useful in the manufacture of smokeless powder, photographic films, artificial leather, artificial silk, and perfumes; applications as a solvent for nitrocellulose, varnishes, lacquers, and aeroplane dopes.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### **ETHYL ACRYLATE (CH<sub>2</sub>=CHCO<sub>2</sub>C<sub>2</sub>H<sub>5</sub>, 100.13)**

**CAS/DOT IDENTIFICATION #:** 140-88-5/UN1917

**SYNONYMS:** ethyl ester of acrylic acid, ethyl propenoate, 2-propenoic acid ethyl ether.

**PHYSICAL PROPERTIES :** colorless liquid; acrid, penetrating odor; transparent, elastic substance; little adhesive power; miscible with alcohol and ether; slightly soluble in water, alcohol, chloroform, and ether; MP (-72°C, -98°F); BP (100°C, 211°F); DN (0.9405 g/cm<sup>3</sup> at 20°C); LSG (0.94); ST (0.025 dynes/cm at 20°C); HV (8.27 kcal/mol); VD (3.45); VP (31 mmHg at 20°C).

**CHEMICAL PROPERTIES:** hazardous polymerization may occur; easily polymerizes on standing; polymerization process accelerated by elevated temperature, sunlight, oxidizers, and peroxides; addition of hydroquinone may inhibit polymerization; uninhibited monomer vapor may polymerize in vents and confined spaces; will react with oxidizing materials, peroxides, polymerizers, strong bases, moisture, and chlorosulfonic acid; FP (9°C, 48°F); LFL/UFL (1.4%, 14.0%); AT (372°C, 702°F); HC (655.49 kcal/mol).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 2; reacts violently with chlorosulfonic acid; vigorous reaction with oxidizing materials; vapors may travel to an ignition source and flash back; liquid floats on water and may travel to an ignition source and spread fire; sealed containers may rupture violently when exposed to heat; use carbon dioxide, dry chemical powder, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and upper respiratory tract); skin absorption (headache, nausea, vomiting, potential occupational carcinogen).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human TDLo 130 ppm; inhalation-human TCLo 50 ppm; toxic effects: nose, eye, pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory tract; wheezing; difficult breathing; chemical pneumonitis; pulmonary edema; inflammation of larynx and bronchi; laryngitis; headache; nausea; vomiting.

**CHRONIC HEALTH RISKS:** labored breath; chest pains; coughing; irritation of gastrointestinal tract; lung and kidney damage; damage to the liver; known EPA carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; STEL 15 ppm; OSHA PEL TWA 25 ppm (100 mg/m<sup>3</sup>)(skin); NIOSH REL potential occupational carcinogen; IDLH 300 ppm.

**PERSONAL PROTECTION:** wear full protective clothing; wear chemical-resistant gloves; wear positive pressure self-contained breathing apparatus; wear splash-proof safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in a sanitary landfill; store away from heat, oxidizers, and sunlight; isolate from oxidizing materials, peroxides, strong acids, and alkalies; outside storage preferred.

**REGULATORY INFORMATION:** CA2; U waste #; (U113); Reportable Quantity (RQ): 1000 lbs (454 kg); Sf1; Sf3; T120-a; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of water emulsion paint for vehicles; used in the production of emulsion based polymers used in textile and paper coatings, leather finish resins and adhesives; imparts flexibility to hard films.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14.

## **ETHYL ALCOHOL (CH<sub>3</sub>CH<sub>2</sub>OH, 46.08)**

**CAS/DOT IDENTIFICATION #:** 64-17-5/UN1170

**SYNONYMS:** alcohol, cologne spirit, ethanol, ethyl hydrate, ethyl hydroxide, grain alcohol, methylcarbinol, molasses alcohol.

**PHYSICAL PROPERTIES :** clear, colorless liquid; very mobile liquid; weak, ethereal, vinous odor; pungent, burning taste; miscible with water, methanol, ether, chloroform, and acetone; MP (-117°C, -179°F); BP (79°C, 174°F); DN (0.7893 g/mL at 20°C); LSG (0.79); ST (22.3 dynes/cm at 20°C); VS (0.0141 poise at 20°C); CP (0.618 cal/g-K liquid at 23°C); HV(42.32 kJ/mol at 25°C); VD (1.6); VP (43 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react vigorously with strong oxidizers; absorbs water rapidly from air; FP (13°C, 55°F); LFL/UFL (3.3%, 19.0%); AT (423°C, 793°F); HF (-277.7 kJ/mol liquid at 25°C); H<sub>f</sub> (5.02 kJ/mol at 159.0K).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; NFPA rating Health 0, Flammability 3, Reactivity 0; vapor mixes well with air, easily forming explosive mixtures; reacts slowly with calcium hypochlorite, silver oxide and ammonia, causing fire and explosion hazard; violent reaction with strong oxidants such as nitric acid, silver nitrate, mercuric nitrate, and magnesium perchlorate; reacts explosively with the oxidized coating around potassium metal; ignites on contact with acetic anhydride and sodium hydrogen sulfate, causing an explosion; reacts violently with acetyl bromide, disulfuryl difluoride, dichloromethane and sulfuric acid, and nitrate or nitrite, and tetrachlorosilane and water; explosive products are formed in reaction with silver (I) oxide and ammonia or hydrazine (forms silver nitride and silver fulminate) and sodium (evolves hydrogen gas); incompatible with bromine pentafluoride, potassium dioxide, platinum, sodium, hydrogen peroxide, nitric acid, acetyl chloride, acetyl bromide, perchlorates, and many others; use large amounts of water, powder, alcohol-resistant foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, drowsiness, headache, fatigue, effects on central nervous system, irritates eyes and respiratory tract); skin contact (dry skin, defatting of skin); eye contact (redness, pain, burning sensation); ingestion (nausea, vomiting, dizziness, headache, confusion, burning sensation, unconsciousness, chronic ingestion may cause liver cirrhosis, repeated ingestions can lead to alcoholism).

**FIRST AID:** flush eyes with plenty of water for several minutes; rinse and then wash skin with plenty of soap and water; if breathing is difficult, give oxygen; if not breathing, give respiratory support; if ingested, rinse mouth and refer for medical attention.

**HUMAN TOXICITY DATA:** oral-man TDLo 700mg/kg; oral-man TDLo 50mg/kg; toxic effect: gastrointestinal tract; oral-man TDLo 1430µg/kg; toxic effect: central nervous system; oral-human LDLo 1400 mg/kg; oral-woman TDLo 256g/kg/12W; toxic effect: central nervous system, endocrine system; oral-woman TDLo 41g/kg (41 W pregnancy); toxic effect: reproductive effects; intrauterine-woman TDLo 200mg/kg (5D pre); toxic effect: reproductive effects; dna inhibition-human lymphocyte 220 mmol/L; subcutaneous-infant LDLo 19,440 mg/kg; toxic effect: central nervous system, metabolic effects.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; cough; drowsiness; headache; fatigue; lassitude; dizziness; inability to concentrate; confusion; alcohol poisoning; loss of appetite; nausea; vomiting; central nervous system depressant; narcosis; loss of consciousness; convulsions.

**CHRONIC HEALTH RISKS:** sleep disorder; hallucinations; distorted perceptions; motor activity changes; ataxia; anti-psychotic effects; headache; pulmonary changes; alteration in gastric secretion; menstrual cycle changes; body temperature decrease; glandular effects; changes in female fertility index; reproductive effects; teratogenic effects; anemia; may cause cirrhosis of the liver; repeated ingestions can lead to alcoholism; effects on newborn include: drug dependence, reproductive effects, changes in apgar score, neonatal measures or effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm (1880 mg/m<sup>3</sup>); OSHA PEL TWA 1000 ppm (1900 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (1900 mg/m<sup>3</sup>); IDLH 3300 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield where splashing is possible; a closed system of ventilation and local exhaust is recommended to control

emissions at the source and to prevent dispersion of it into the general work area; use explosion-proof electrical equipment and lighting; do not use compressed air for filling, discharging, or handling; use self-contained breathing apparatus operated in positive pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** collect leaking and spilled liquid in sealable containers as far as possible; wash away remaining liquid with plenty of water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb with noncombustible absorbent material and place in a sanitary landfill; store in a cool, dry, well-ventilated area; storage should be in a standard flammable liquid storage room or cabinet; keep containers tightly closed; separate from strong oxidants; avoid open flames, sparks, and other sources of ignition.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** mostly used in alcoholic beverages in suitable dilutions; also used as a solvent for resins, fats, fatty acids, oils and hydrocarbons; other uses include the manufacture of acetaldehyde, acetic acid, ethylene, butadiene, 2-ethyl hexanol, dye, pharmaceuticals, elastomers, detergents, cleaning preparations, surface coatings, cosmetics, and explosives; useful as an octane booster in gasoline.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

## **ETHYLAMINE (CH<sub>3</sub>CH<sub>2</sub>NH<sub>2</sub>, 45.10)**

**CAS/DOT IDENTIFICATION #:** 75-04-7/UN1036, UN2270

**SYNONYMS:** aminoethane, ethanamine, monoethylamine.

**PHYSICAL PROPERTIES :** colorless gas; water-white liquid below 62°F; strong ammonia-like odor; miscible with water, alcohol, and ether; salted out by sodium hydroxide; MP (-81°C, -114°F); BP (16.6°C, 62°F); DN (0.689 g/mL at 15°C); LSG (0.69); ST (21.3 dynes/cm at 0°C, 20.4 dynes/cm at 9.9°C in contact with nitrogen); CP (130.0 J/K-mol liquid at 25°C, 71.5 J/K-mol gas at 25°C); HV (6,845.1 gcal/gmol); VD (1.56); VP (873 mmHg at 20°C); OT (2.70 x 10<sup>-1</sup> ppm in air).

**CHEMICAL PROPERTIES:** flammable gas or liquid; pure material and aqueous solutions are corrosive; can react vigorously with oxidizing materials; reacts with acids, chlorine, hypochlorite, halogenated compounds, reactive organic compounds, and some metals; strong alkaline reaction; FP (-17.2°C, 1.0°F); LFL/UFL (3.5%, 14.0%); AT (385°C, 725°F); HC (409.5 kcal/gmol liquid at 25°C); HF (-74.1 kJ/mol liquid at 25°C, -47.5 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable gas above 62°F (17°C); NFPA rating Health 3, Flammability 4, Reactivity 0; flashback along vapor trail may occur; vapor may explode if ignited in a confined area; very dangerous fire hazard; aqueous solutions are flammable unless diluted extensively; moderate explosion hazard when exposed to spark or flame; incompatible with cellulose nitrate, strong oxidizers, and copper, tin and zinc in presence of moisture; heating to decomposition emits toxic fumes of oxides of nitrogen; use water spray, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of respiratory tract and lungs, pulmonary edema); skin absorption (severe irritation and burns of eyes and skin, dermatitis); ingestion (severe burns of mouth and stomach).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if ingested, drink large amounts of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans; inhalation-unspecified  $LC_{50}$  2300 mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; coughing; nausea; pulmonary edema; skin and eye burns; severe burns of mouth and stomach.

**CHRONIC HEALTH RISKS:** permanent eye injury; dermatitis; toxic effect: eyes, skin and respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; ACGIH TLV STEL 15 ppm (skin); OSHA PEL TWA 10 ppm (18mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (18 mg/m<sup>3</sup>); IDLH 600 ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear full protective clothing, including chemical resistant gloves; use chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; flush remaining spill with large amounts of water and dilute to form nonflammable mixtures; overspread spill with sufficient sodium bisulfate and sprinkle with water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** add contaminated amine to layer of sodium bisulfate, spray with water, neutralize, and route to sewage plant; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; separate from oxidizing materials, acids, and sources of halogens; should be stored in tightly closed containers and kept in a cold place.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (2.1); labels (flammable gas, UN1036); DOT hazard class/division (3); labels (flammable liquid, UN2270).

**OTHER COMMENTS:** used in resin chemistry; used as a chemical intermediate for dyestuffs and medicinals; used as a stabilizer for rubber latex; useful in solvent extraction, petroleum refining, detergents, and organic synthesis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 11; 14.

### **EHTYL AMYL KETONE (C<sub>2</sub>H<sub>5</sub>COCH<sub>2</sub>CH(CH<sub>3</sub>)CH<sub>2</sub>CH<sub>3</sub>, 128.24)**

**CAS/DOT IDENTIFICATION #:** 541-85-5/UN2271

**SYNONYMS:** amyl ethyl ketone, ethyl sec-amyl ketone, ethyl 2-methylbutyl ketone, 2-methylbutyl ethyl ketone, 3-methyl-5-heptanone, 5-methyl-3-heptanone.

**PHYSICAL PROPERTIES:** clear, colorless liquid; strong, pungent odor; other references report that the odor is mild and fruity, resembling essence of peaches and apricots; very slightly soluble in water; soluble in 4 volumes of 60% alcohol slightly soluble in ether; infinite solubility in organic solvents; MP (-56.7°C, -70.1°F); BP (157 - 162°C, 314.6 - 323.6°F); DN (0.820 - 0.824 g/mL at 20°C); LSG (0.822 at 20°C); BULK DN (83 lb/gal); MAXVP CONC (2,600 ppm at 20°C); VP ( 2mmHg at 20°C); OT (5 ppm).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization may occur; can react vigorously with strong oxidizers, such as perchlorates, peroxides, nitrates, chlorates, and permanganates; FP (58°C, 138°F); LFL/UFL (unknown); AT (unknown); HC (unknown); IR (1.4160 at 20°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating (not rated); vapors may form explosive mixtures with air; flashback along vapor trail may occur; vapor explosion hazard indoors, outdoors or in sewers; containers may explode in fire; runoff to sewer may create fire or explosion hazard; liquid is flammable when exposed to heat, sparks, or flame; violent reaction with oxidizers, such as perchlorates, peroxides, chlorates, nitrates, and permanganates; poisonous gases are produced in fire, including carbon monoxide; use dry chemical, carbon dioxide, or alcohol or polymer foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, coughing, difficult in breathing, bronchitis, bronchospasm, wheezing, pneumonitis); eye contact (pain, swelling, lacrimation, photophobia); skin contact (skin rash, drying and cracking of skin); ingestion (irritates gastrointestinal tract, depression of central nervous system).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; immediately wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure. (Note: the maximum tolerated human exposure to this agent has not been described).

**ACUTE HEALTH RISKS:** irritation to eyes, skin and mucous membranes; can irritate nose and throat causing coughing and shortness of breathing; exposure can cause headache, nausea, dizziness, lightheadedness, respiratory depression, ataxia, anesthesia, narcosis, coma and death.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact can cause a skin rash and drying and cracking of skin; chronic effects may include reduced memory and concentration, personality changes (withdrawal, irritability), fatigue, sleep disturbances, reduced coordination, and effects on nerves supplying internal organs (autonomic nerves) and/or nerves to the arms and legs (weakness, "pins and needles").

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm (131 mg/m<sup>3</sup>); OSHA PEL TWA 25 ppm (130 mg/m<sup>3</sup>); NIOSH REL TWA 25 ppm (130 mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, solvent-resistant gloves, lab coat; wear splash-proof safety goggles when working with liquids; enclose operations and use local exhaust ventilation at site of chemical release; use only non-sparking type tools and equipment, especially when opening and closing containers; appropriate respirators are needed in areas where the potential exists for exposure over 25 ppm; if the possibility of exposure is above 100 ppm exists, use self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; vapor suppressing foam may be used to reduce vapors; absorb or cover liquids with non-combustible materials (e.g., dry earth, sand, vermiculite), and transfer to chemical waste containers; use clean non-sparking tools to collect absorbed materials; flush remaining spill with large amounts of water but not into confined spaces such as sewers due to possibility of explosion; remove all sources of ignition (e.g., flares, sparks or flames).

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and dispose of in a secured, sanitary landfill; this compound should be stored in tightly closed containers in a cool, well-ventilated area; use only non-sparking type tools and equipment when opening and closing containers of this compound; keep away from any area where the fire hazard may be acute; separate from oxidizing agents (such as perchlorates, peroxides, permanganates, chlorates, nitrates, chlorine, bromine, and fluorine), strong bases (such as sodium hydroxide and potassium hydroxide), and reducing agents.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** often used as a solvent for nitrocellulose - alkyd, vinyl resins, and nitrocellulose - maleic; used as a chemical intermediate in many organic reactions; this compound is also used to make perfumes.

**KEY REFERENCES:** 4; 5; 6; 7; 14; 15.

### **ETHYLBENZENE (CH<sub>3</sub>CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>, 106.2)**

**CAS/DOT IDENTIFICATION #:** 100-41-4/UN1175

**SYNONYMS:** eb, ethylbenzol, phenylethane.

**PHYSICAL PROPERTIES :** colorless liquid; aromatic odor; miscible in ethyl alcohol, ethyl ether, benzene, and carbon tetrachloride; soluble in sulfur dioxide; insoluble in ammonia and water; MP (-95°C, -139°F); BP(136°C, 277°F); DN (0.8669 g/mL at 20°C); LSG (0.87); ST (31.50 dynes/cm); VS (0.64 cP at 25°C); CP (183.2 J/K-mol liquid at 25°C); HV (9301.3 g/cal/gmole); VD (3.66); VP (7 mmHg at 20°C).

**CHEMICAL PROPERTIES:** reacts strongly with oxidizing materials; FP (21°C, 70°F); LFL/UFL (1.0%, 6.7%); AT (432°C, 810°F); HC (-9877 cal/g, -413.5 x 10<sup>3</sup> J/kg); HF (-12.3 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; may accumulate static electricity; vapors may travel to an ignition source and flash back; liquid floats on water and may travel to an ignition source and spread fire; can react vigorously with oxidizing materials; decomposition may produce irritants and toxic gases; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); ingestion (headache, dermatitis, narcosis, coma).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 100ppm/8H; toxic effects: eye, central nervous system, pulmonary system; sce-human lymphocyte 1mmol/L.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and mucous membranes; headache; dermatitis; narcosis; coma.

**CHRONIC HEALTH RISKS:** central nervous system depression; death in high exposures.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; STEL 125 ppm; OSHA PEL TWA 100 ppm (435mg/m<sup>3</sup>); STEL 125 ppm; NIOSH REL TWA 100 ppm (435 mg/m<sup>3</sup>); STEL 125 ppm (545 mg/m<sup>3</sup>); IDLH 800 ppm.

**PERSONAL PROTECTION:** wear boots, chemical-resistant gloves, sleeves, aprons, etc.; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; flush remaining ethylbenzene with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; atomize large amounts in a suitable combustion chamber equipped with afterburner and scrubber; outside storage preferred; inside storage should be in a standard flammable liquids storage room or cabinet; separate from oxidizing materials.

**REGULATORY INFORMATION:** CA2; S2; S32; S50-b; S61; S62; S10; R2; R3; R4; Reportable Quantity (RQ): 1000 lbs (454 kg); Sfl; Sf3; CW1; CW2; CW3; CW4; A1; CAL; DOT hazard class/division (3); labels (flammable and combustible liquid).

**OTHER COMMENTS:** used in the conversion to styrene monomer; used as a component of automotive and aviation fuels; used in the manufacture of cellulose acetate; used as a solvent for propylene oxide and alpha-methylbenzene alcohol; used as a chemical intermediate for diethylbenzene and acetophenone.

**KEY REFERENCES:** 1; 2; 3; 4; 5; 6; 7; 9; 10; 11; 12; 13; 14.

## **ETHYL BROMIDE (CH<sub>3</sub>CH<sub>2</sub>Br, 108.98)**

**CAS/DOT IDENTIFICATION #:** 74-96-4/UN1891

**SYNONYMS:** bromic ether, bromoethane, halon 2001, hydrobromic ether, monobromoethane

**PHYSICAL PROPERTIES:** colorless liquid; turns yellowish when exposed to light and air; ethereal odor; burning taste; exists as a gas above 101°F (38.3°C); sparingly soluble in water; miscible in chloroform, alcohol, ether and other organic solvents; MP (-119°C, -182°F); BP (38.2°C, 100.8°F); DN (1.4612 g/mL at 20°C); LSG (1.46); ST (24.15 dyne/cm at 20°C); VS (0.379 cP at 25°C); CP (100.8 J/K-mol liquid at 25°C); HV (28.03 kJ/mol at 25°C); VD (3.76); VP (467 mmHg at 25°C); OT (890 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with oxidizing materials; can react with sodium, potassium, calcium, powdered aluminum, zinc and magnesium; FP (-20°C, -4°F); LFL/UFL (6.8%, 8.0%); AT(511°C, 952°F); HF (-90.1 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** highly volatile flammable liquid; NFPA rating Health 2, Flammability 1, Reactivity 0; moderately explosive when exposed to flame; liquid will

attack some forms of plastic, rubber and coatings, mixture of this substance with alkali metals will cause an explosion that may occur by an impact; produces toxic and corrosive fumes upon reaction with water or steam; contact with chemically-active metals such as sodium, potassium, calcium, powdered aluminum, zinc, and magnesium may cause fires and explosions; vigorous interaction of ethanol, phosphorus, and bromine to yield bromoethane is considered too dangerous for a school experiment; readily decomposes into hydrobromic acid and bromine, especially in presence of hot surfaces; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use carbon dioxide, dry chemical or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, pulmonary edema, coughing, difficult breathing, nausea, burning of eyes and flow of tears, narcosis, severely irritates respiratory system); eye contact (hemorrhages in conjunctiva, conjunctival irritation); skin absorption (speech disorders, numbness, vertigo, sensitivity disorder, muscular weakness, finger tremor, pathological reflexes, cardiac arrhythmia, anesthetic effects); ingestion (damage to the liver, kidneys and heart).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes or normal saline; immediately wash affected areas of skin with plenty of soap or mild detergent and large amounts of water; if breathing is difficult, provide oxygen; begin artificial respiration if breathing has stopped; in case of ingestion, induce vomiting by giving syrup of ipecac, followed by water; seek medical attention immediately.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes skin, and respiratory system; redness of face; dilation of pupils; rapid pulse; cyanosis; respiratory disorder; respiratory paralysis; collapse; pulmonary edema; slight headache; vertigo; dizziness; slurred speech; anesthesia; cardiac arrest; depression of central nervous system; conjunctival hyperemia; hemorrhages in conjunctiva; loss of consciousness; death.

**CHRONIC HEALTH RISKS:** kidney and/or liver damage; weakness; staggering gait; spasmodic paresis accompanied by muscular weakness; speech disorders; nystagmus; finger, muscle fiber tremor; leg weakness; sensitivity disorders, numbness; cranial nerve problems; somnolence; vertigo; fatty degeneration of the liver, renal tissue, and the heart.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (22 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 200 ppm (890 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, rubber gloves, lab coat, apron or coveralls; use splash-proof safety goggles where liquid ethyl bromide may contact the eyes; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in unknown or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; vapor suppressing foam may be used to reduce vapors; absorb or cover liquids with non-combustible materials (e.g., dry earth, sand, vermiculite), and transfer to containers for later disposal; use clean non-sparking tools to collect absorbed materials; prevent entry into waterways or confined areas such as sewers and basements; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of by atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; store in tightly closed containers at room temperatures; use only with adequate ventilation; large quanti-

ties should be stored out of doors, shielded from direct exposure to sunlight and away from areas where the fire hazard may be acute; separate from readily oxidizable materials and chemically active metals (such as potassium, sodium, zinc, calcium, magnesium, and powdered aluminum); indoor storage should be in a standard flammable liquid storage room or cabinet.

**REGULATORY INFORMATION:** T30-e10; T120-d10; A1; CAL; DOT hazard class/division (6.1); label (poison).

**OTHER COMMENTS:** used in the ethylation of gasoline; used as a solvent for fats, waxes, and resins; use as a liquid fumigant for grain and fruit; applications as a chemical intermediate in the manufacture of pharmaceuticals; formerly used as a topical and inhalation anesthetic.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14; 15; 16.

### **ETHYL BUTYL KETONE (CH<sub>3</sub>(CH<sub>2</sub>)<sub>3</sub>COCH<sub>2</sub>CH<sub>3</sub>, 114.21)**

**CAS/DOT IDENTIFICATION #:** 106-35-4/UN1224

**SYNONYMS:** butyl ethyl ketone, ethyl n-butyl ketone, heptan-3-one, 3-heptanone.

**PHYSICAL PROPERTIES :** clear, colorless liquid; possesses good mobility; powerful fruity odor; soluble in alcohol and ether; poor solubility in water; solubility in water increases at higher temperatures (i.e., miscible with water at 149°C); MP (-39°C, -38°F); BP (149-152°C, 300-305.6°F); DN (0.8198 g/mL at 20°C); LSG (0.82); VD (3.93); VP (4 mmHg at 20°C); RELDN of vapor/air mixture (1.01 at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react with strong oxidizing materials; FP (46°C, 115°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** flammable, combustible liquid; NFPA rating Health 1, Flammability 2, Reactivity 0; moderate fire risk; explosive vapor/air mixtures may be formed above 46°C, incompatible with oxidizers, acetaldehyde and perchloric acid; use foam, carbon dioxide or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, dizziness, headache, sore throat, unconsciousness); skin contact (dry skin, redness, dermatitis); eye contact (redness, pain).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of water or shower; if breathing is difficult, provide oxygen; give artificial respiration as indicated; if swallowed, rinse mouth and get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory tract; irritation of mucous membranes; cough dizziness; headache; sore throat; may cause effects on central nervous system; lowering of consciousness; coma.

**CHRONIC HEALTH RISKS:** may cause dermatitis; targets eyes, skin, respiratory system, and central nervous system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (234 mg/m<sup>3</sup>); OSHA PEL TWA 50 ppm (230 mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (230 mg/m<sup>3</sup>); IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear chemical safety goggles in combination with breathing protection; a closed system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; use explosion-proof electrical equipment; use positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect as much as possible of leaking and spilled liquid in sealable metal container; absorb remaining liquid with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; do not wash away into sewers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in dry sand or other inert absorbent and place in a sanitary landfill; store in a cool, dry location; maintain adequate ventilation; fireproof if in building; separate from oxidizing materials; avoid sparks and open flames.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used as a solvent mix for polyvinyl and nitrocellulose resins, and for air-dried and baked finishes.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### **ETHYL CHLORIDE (CH<sub>3</sub>CH<sub>2</sub>Cl, 64.52)**

**CAS/DOT IDENTIFICATION #:** 75-00-3/UN1037

**SYNONYMS:** chloroethane, hydrochloric ether, monochloroethane, muriatic ether.

**PHYSICAL PROPERTIES :** colorless liquid or gas; mobile; very volatile liquid at low temperatures or under increased pressure; ethereal odor; burning taste; miscible in alcohol and ether; slightly soluble in water; MP (-138.7°C, -217.7°F); BP (12.3°C, 54°F); DN (0.9214 g/mL at 0°C); LSG (0.92 at 32°F); VS (0.258 mPa-s at 25°C); CP (104.3 J/K-mol at 25°C); HV (24.65 kJ/mol at 285.4K); VD (2.22); VP (1000 mmHg at 20°C).

**CHEMICAL PROPERTIES:** volatile at room temperature; stable and noncorrosive when dry; reacts with chemically-active metals such as sodium, potassium, calcium, powdered aluminum, zinc, and magnesium; also reacts with strong oxidizers, water or steam; reacts with water to form hydrochloric acid; FP (-50°C, -58°F); LFL/UFL (3.6%, 14.8%); AT (519°C, 966°F); HF (-136.5 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid or gas; NFPA rating Health 2, Flammability 4, Reactivity 0; dangerous fire hazard when exposed to heat or flame; severe explosion hazard; reacts vigorously with oxidizing materials; reacts with water or steam to produce toxic and corrosive fumes; incompatible with potassium; decomposition emits toxic fumes of phosgene and Cl<sup>-</sup>; carbon dioxide is recommended for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and mucous membranes); skin absorption (cramps, cardiac arrhythmia, cardiac arrest).

**FIRST AID:** immediately flush eyes with large amounts of water; wash affected areas of skin with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** no data regarding toxicity values in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes and upper respiratory tract; abdominal cramps; incoordination; inebriation; nausea; vomiting; headache.

**CHRONIC HEALTH RISKS:** cardiac arrhythmias; cardiac arrest; liver and kidney damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm; OSHA PEL TWA 1000 ppm (2600 mg/m<sup>3</sup>); NIOSH REL TWA handle with caution in the workplace; IDLH 3800 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, i.e., boots, aprons, chemical-resistant gloves, etc.; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; consult an expert with regard to clean up procedures.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; fireproof if in building; separate from oxidants, alkaline metals, calcium, magnesium, aluminum powder, and zinc; keep away from water and other sources of moisture.

**REGULATORY INFORMATION:** CA2; R3; Reportable Quantity (RQ): 100 lbs. (45.4kg); Sfl; A1; CAL; DOT hazard class/division (2.1); labels (flammable gas).

**OTHER COMMENTS:** used in the manufacture of tetraethyl lead and ethylcellulose; used as a solvent, refrigerant, and alkylating agent.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 9; 12; 13; 14.

## **ETHYL ETHER (C<sub>2</sub>H<sub>5</sub>OC<sub>2</sub>H<sub>5</sub>, 74.14)**

**CAS/DOT IDENTIFICATION #:** 60-29-7/UN1155

**SYNONYMS:** anesthetic ether, diethyl ether, diethyloxyde, ether, ethyl ether, ethyl oxide, solvent ether.

**PHYSICAL PROPERTIES :** colorless, mobile liquid; hygroscopic; floats on water; gas above 94°F; vapor heavier than air; pungent, sweetish odor, more agreeable than chloroform; burning and sweet taste; miscible with aliphatic alcohols, benzene, chloroform, petroleum ether, solvent naphtha, other fat solvents, and many oils; slightly soluble in water; forms an azeotrope with water; soluble in concentrated hydrochloric acid; solubility in water increased by hydrochloric acid; MP (-116.3°C, -177.3°F); BP (34.6°C, 94.3°F); DN (0.7135 g/mL at 20°C); LSG (0.71); ST (17.06 dynes/cm at 20°C); VS (0.2448 cP at 20°C); CP (175.6 J/K-mol liquid at 25°C); HV (89.80 cal/g at 30°C); VD (2.56); VP (184.9 mmHg at 0°C, 290.8 mmHg at 10°C, 439.8 mmHg at 20°C, 1276 mmHg at 50°C, 2304 mmHg at 70°C).

**CHEMICAL PROPERTIES:** flammable liquid; produces considerable coldness on quick evaporation; can react vigorously with acetyl peroxide, air, bromoazide, chlorine trifluoride, chromium trioxide, lithium aluminum hydride, potassium peroxide, sulfuric acid and permanganates, and oxygen; stabilized by the addition of naphthols, polyphenols, aromatic amines and aminophenols; FP (-45°C, -49°F); LFL/UFL (1.9%, 36.0%); AT (180-190°C, 356-374°F); HC (-8.807 kcal/g); HF (-279.3 kJ/mol liquid at 25°C); T<sub>c</sub> (192.7°C, 379°F); P<sub>c</sub> (35.6 atm, 27,056 mmHg).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; NFPA rating Health 1, Flammability 4, Reactivity 1; very dangerous fire and explosion hazard; flashback along vapor

trail may occur; liquid floats on water; may travel to an ignition source and spread fire; tends to form explosive peroxides upon exposure to air and light; evaporation to dryness will result in peroxide formation; dangerous storage hazard; formation of peroxides may occur in containers that have been opened and remain in storage greater than six months; peroxides can be detonated by heating, friction, or impact; shaking under thoroughly dry conditions can result in the generation of static electricity; may explode when brought in contact with anhydrous nitric acid; can react violently or ignites on contact with halogens, interhalogens, oxidants, sulfur and sulfur compounds; auto-oxidizes to form explosive polymeric 1-oxy-peroxides; explosive reaction with boron triazide, bromine trifluoride, bromine pentafluoride, perchloric acid, and wood pulp extracts and heat; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (confusion, dizziness, lack of coordination, intoxication, drowsiness, stupor, unconsciousness); ingestion (nausea, vomiting).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** eye-human 100 ppm; oral-human LDLo 420 mg/kg; inhalation-human TLo 200 ppm; toxic effect: nose; oral-man LDLo 260 mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory system; dizziness; drowsiness; headache; nausea; vomiting; excitedness; narcosis; confusion; lack of coordination; loss of consciousness; death in high concentrations.

**CHRONIC HEALTH RISKS:** olfactory changes; central nervous system depression; chronic respiratory disease.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 400 ppm; ACGIH TLV STEL 500 ppm; OSHA PEL TWA 400 ppm (1200mg/m<sup>3</sup>); IDLH 1900 ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear full protective clothing, including chemical resistant gloves; splash-proof safety goggles are recommended.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dissolve in flammable solvent, such as alcohol, and atomize in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from oxidizing materials; avoid exposure to sunlight.

**REGULATORY INFORMATION:** S10; U waste # (U117); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for waxes, oils, fats, gums, perfumes, and alkaloids; an excellent solvent for nitrocellulose when mixed with alcohol; useful in organic syntheses, especially as a reagent in Grignard and Wurtz type reactions; used in the production of drugs of abuse, in the manufacture of gun powder, and as a primer for gasoline engines; applications as an extractant of hormones, etc. from plant and animal tissues; has also been used as an anesthetic.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 14.

**ETHYL FORMATE (CH<sub>3</sub>CH<sub>2</sub>OCHO, 74.09)****CAS/DOT IDENTIFICATION #:** 109-94-4/UN1190**SYNONYMS:** ethyl ester of formic acid, ethyl methanoate, formic ether.

**PHYSICAL PROPERTIES :** colorless or water-white, mobile liquid; sharp, pleasant, rum-like odor; miscible in ethanol, diethyl ether, and benzene; slightly soluble in water; MP (-80°C, -112°F); BP (54°C, 129°F); DN (0.9236 g/mL at 20°C); LSG (0.92); ST (23.18 mN/m at 25°C); VS (0.380 mPa-s at 25°C); HV (31.96 kJ/mol at 25°C); VD (2.55); VP (194 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts vigorously with strong nitrates, strong oxidizers, strong alkalis, and strong acids; decomposes slowly in water to form ethyl alcohol and formic acid; FP (-20°C, -4°F); LFL/UFL (2.8%, 16.0%); AT (455°C, 851°F); HF (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** extremely flammable liquid and vapor; NFPA rating Health 2, Flammability 3, Reactivity 0; vapor may cause flash fire; dangerous fire and explosion risk when exposed to heat or flame; above flash point, vapor-air mixtures are explosive within flammable limits; sensitive to static discharge; sealed containers may rupture when heated; contact with strong oxidizers may cause fire; contact with strong nitrates, strong alkalis, and strong acids may cause fire and explosions; incompatible with heat, flames, and ignition sources; carbon dioxide and carbon monoxide may form when heated to decomposition; use dry chemical, alcohol foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract, drowsiness, loss of consciousness, affects central nervous system); skin/eye contact (irritation, redness, pain, itching); ingestion (irritates gastrointestinal tract, affects central nervous system).

**FIRST AID:** flush eyes immediately with plenty of water; immediately flush skin with large amounts of soap and water; if breathing is difficult, provide oxygen; if not breathing, give respiratory support; if ingested, induce vomiting immediately and get medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of nose and throat; irritation of gastrointestinal tract; irritation to skin, including redness, itching, and pain; causes eye irritation, including redness and pain; may affect central nervous system; drowsiness; loss of consciousness; persons with pre-existing skin disorders or eye problems, or impaired kidney, liver or respiratory function may be more susceptible to the effects of ethyl formate.

**CHRONIC HEALTH RISKS:** no information found regarding chronic exposure in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100ppm; OSHA PEL TWA 100 ppm (300 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (300mg/m<sup>3</sup>); IDLH 1500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, proper gloves, lab coat, apron or coveralls; wear positive pressure self-contained breathing apparatus if the exposure limit is exceeded; maintain eyewash fountains and quick-drench facilities in immediate work area; use non-sparking tools and equipment.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect liquid in an appropriate container or absorb with noncombustible materials (e.g., dry earth, sand or vermiculite), and place in

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a chemical waste container; do not use combustible materials, such as saw dust and do not flush to sewer; if leak or spill has not ignited, use water spray to disperse vapors; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb with an inert material (e.g., dry sand, earth, vermiculite), and place in a chemical waste container or in a secured, sanitary landfill; whatever cannot be saved for recovery or recycling should be managed in an approved waste disposal facility; store in a cool, dry location with adequate ventilation; keep away from any area where the fire hazard may be acute; outside storage is preferred; containers should be bonded and grounded for transfers to avoid static sparks; use non-sparking type tools and equipment, including explosion proof ventilation; separate from heat, flames, ignition sources and incompatibles.

**REGULATORY INFORMATION:** F7; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose nitrate and acetate; used as a flavor for lemonades and essence and for the manufacture of artificial rum; also used as a substitute for acetone, as a fungicide and larvicide, and as a laboratory reagent; useful in organic synthesis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### ETHYL MERCAPTAN (CH<sub>3</sub>CH<sub>2</sub>SH, 62.13)

**CAS/DOT IDENTIFICATION #:** 75-08-1/UN2363

**SYNONYMS:** ethanethiol, ethyl sulfhydrate, ethyl thioalcohol, mercaptoethane, thioethanol, thioethyl alcohol.

**PHYSICAL PROPERTIES :** colorless liquid; strong skunk-like odor; a gas above 95°F; soluble in ethanol, diethyl ether, alkalis, and petroleum naphtha; forms an azeotrope with n-pentane (51% ethanethiol, BP 30.46°C) and with ether (40% ethanethiol, BP 31.50°C); MP (-144.4°C, -228°F); BP (36°C, 97°F); DN (0.83907 g/mL at 20°C); LSG (0.839); ST (23.63 dynes/cm at 2°C, 21.62 dynes/cm at 16.7°C); VS (0.003155 g/cm-sec at 20°C); CP (117.9 J/K-mol liquid at 25°C); HV (27.3 kJ/mol at 25°C); VD (2.14); VP (442 mmHg at 20°C); OT (1 part in 50 billion parts of air).

**CHEMICAL PROPERTIES:** substance is a weak acid; can react vigorously with oxidizing materials and strong acids; produces oxides of sulfur and hydrogen sulfide on decomposition; FP (-48.3°C, -55°F); LFL/UFL (2.8%, 18.0%); AT (299°C, 570°F); HF (-73.6 kJ/mol liquid at 25°C); H<sub>f</sub> (4.98 kJ/mol at 125.26K); T<sub>c</sub> (225.5°C, 438°F); P<sub>c</sub> (54.2 atm, 41,192 mmHg).

**EXPLOSION and FIRE CONCERNS:** extremely flammable liquid; NFPA rating Health 2, Flammability 4, Reactivity 0; very dangerous fire risk when exposed to heat or flame; moderately explosive when exposed to sparks and open flame; vapor/air mixtures are explosive; vapor is heavier than air and may travel along the ground to a source of ignition; reacts with oxidants causing fire and explosion; reaction with strong acids evolves toxic and flammable hydrogen sulphide; reacts violently with calcium hypochlorite; will react with water or steam to produce toxic and flammable vapors; decomposes on heating or on burning to produce toxic fumes including oxides of sulfur and hydrogen sulfide; use carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (central nervous system effects, headache, dizziness, difficult breathing, irritates mucous membranes); skin/eye contact (redness, pain); ingestion (nausea, vomiting, weakness, unconsciousness).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; wash affected areas of skin with plenty of soap and water; provide oxygen or artificial respiration if indicated; if ingested, do not induce vomiting and get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of mucous membranes; headache; nausea; vomiting; dizziness; loss of consciousness; narcosis; incoordination; cyanosis.

**CHRONIC HEALTH RISKS:** liver damage; damage to the kidneys; targets eyes, respiratory system, liver, kidneys, and blood.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (1.3 mg/m<sup>3</sup>); OSHA PEL CL 10 ppm (25 mg/m<sup>3</sup>); NIOSH REL CL 0.5 ppm/15M (1.3mg/m<sup>3</sup>/15M); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, proper gloves, lab coat, apron or coveralls; use chemical safety goggles and/or full face shield where splashing is possible; wear positive pressure self-contained breathing apparatus if the exposure limit is exceeded; maintain eyewash fountains and quick-drench facilities in immediate work area; use explosion-proof electrical equipment and lighting.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking liquid in sealable containers; absorb remaining liquid in an inert absorbent, such as dry earth, sand or vermiculite, and remove to safe place; do not wash away into spaces such as sewers because of danger of explosion.

**DISPOSAL AND STORAGE METHODS:** absorb in noncombustible materials (such as sand or other inert absorbents), and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; storage should be in a fireproof room or cabinet; separate from strong oxidants, strong bases, and strong acids.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a chemical intermediate and starting material in the manufacture of plastics, insecticides and antioxidants; also used as an odorant for natural gas; useful as an adhesive and as a stabilizer.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

## **ETHYL SILICATE ((C<sub>2</sub>H<sub>5</sub>)<sub>4</sub>SiO<sub>4</sub>, 208.37)**

**CAS/DOT IDENTIFICATION #:** 78-10-4/UN1292

**SYNONYMS:** ethyl orthosilicate, silicic acid tetraethyl ester, tetraethoxysilane, tetraethyl orthosilicate, tetraethyl silicate.

**PHYSICAL PROPERTIES :** clear, colorless liquid; sharp, alcohol-like odor; miscible with alcohol; practically insoluble in water; MP (-86°C, -123°F); BP (169°C, 336°F); DN (0.933 g/mL at 20°C); LSG (0.93); VS (0.0179 cP at 20°C); VD (7.2); VP (2 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with water to form an adhesive form of silica; slowly decomposed by water; can react vigorously with strong oxidizers; FP (39°C, 102°F); LFL/UFL (unknown); AT (238°C, 460°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 2, Reactivity 0; combustible; flashback along vapor trail may occur; closed containers may explode when exposed to heat; contact with strong oxidizers may cause fire; incompatible with water, alkalies, mineral acids, and strong oxidizing agents; hazardous decomposition products include carbon monoxide, carbon dioxide, and oxides; use alcohol foam, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, nausea, vomiting, dizziness); contact (tremor, narcotic effects, irritation, liver damage, damage to kidneys); ingestion (nausea, vomiting)

**FIRST AID:** flush eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if ingested, induce vomiting and get medical attention.

**HUMAN TOXICITY DATA:** eye-human 3000 ppm.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and nose; headache; nausea; vomiting; dizziness; in animals: pulmonary edema; tremors; narcosis; lacrimation; difficulty breathing.

**CHRONIC HEALTH RISKS:** kidney damage; liver damage; anemia; targets kidneys, blood, and skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm; OSHA PEL TWA 100 ppm (850 mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (85 mg/m<sup>3</sup>); IDLH 700 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield where splashing is possible; a closed system of ventilation and local exhaust is recommended to control emissions at the source and to prevent dispersion of it into the general work area; use self-contained breathing apparatus operated in positive pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** stop leak if possible; use water spray to cool and reduce vapors; absorb with noncombustible absorbent material (e.g. sand), and place into container for later disposal; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility; store in a cool, dry, well-ventilated area; storage should be in a standard flammable liquid storage room or cabinet; keep container tightly closed; separate from incompatibles and avoid heat, flame and other sources of ignition.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of weatherproof and acid-proof mortars and cements, refractory bricks, heat-resistant and chemical-resistant paints, lacquers, and protective coatings for industrial buildings and castings; also used in hardening stone; useful in arresting decay and disintegration.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

## **ETHYLENE CHLOROHYDRIN (CICH<sub>2</sub>CH<sub>2</sub>OH, 80.52)**

**CAS/DOT IDENTIFICATION #:** 107-07-3/UN1135

**SYNONYMS:** 2-chloroethanol, 2-chloroethyl alcohol, ethylene glycol chlorohydrin, glycol chlorohydrin, glycol monochlorohydrin

**PHYSICAL PROPERTIES :** colorless liquid; faint; ethereal odor; soluble in most organic liquids; completely miscible with water; MP (-68°C, -90°F); BP (128-130°C, 262-266°F); DN (1.197 g/mL at 20°C); LSG (1.20); HV (41.43 kJ/mol at 401.7K); VD (2.8); BP (5 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with oxidizing materials, acids, and bases; FP (60°C, 140°F); LFL/UFL (4.9%, 15.9%); AT (425°C, 797°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; flammable liquid when exposed to heat, flame or oxidizers; NFPA rating Health 4, Flammability 2, Reactivity 0; reacts with water or steam to produce toxic fumes; reacts violently with chlorosulfonic acid, ethylene diamine, sodium hydroxide, and oxidants; decomposes on heating or on burning, producing highly toxic gases, such as hydrogen chloride and phosgene; use water spray, alcohol-resistant foam, powder or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, dizziness, headache, nausea, vomiting, shortness of breath, sore throat, visual disturbance, respiratory paralysis, low blood pressure); skin absorption (symptoms parallel those of inhalation); contact (severe deep eye burns, redness, pain); ingestion (symptoms parallel those of inhalation).

**FIRST AID:** rinse eyes with plenty of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if swallowed, rinse mouth and induce vomiting.

**HUMAN TOXICITY DATA:** inhalation-man LCLo 305 ppm/2H.

**ACUTE HEALTH RISKS:** irritation of mucous membranes; cough, dizziness; headache; shortness of breath; sore throat; nausea; vomiting; pain in head and chest; vertigo; respiratory failure; low blood pressure; visual disturbance; incoordination; numbness; thirst; delirium; collapse; shock; coma; may result in death.

**CHRONIC HEALTH RISKS:** can affect central nervous system; kidney damage; damage to the liver; can affect spleen and lungs; experimental teratogenic effects have been found.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 1 ppm (3.3 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 5ppm (16mg/m<sup>3</sup>)(skin); NIOSH REL CL 1ppm (3mg/m<sup>3</sup>)(skin); IDLH 7 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles, face shield, or eye protection in combination with breathing protection; use positive pressure self-contained breathing apparatus in high vapor concentrations; above 60°C, a closed system of local exhaust ventilation is preferred; explosion-proof electrical equipment is recommended.

**SPILL CLEAN-UP:** collect liquid in appropriate sealable containers as far as possible; absorb remaining liquid in an inert material (e.g., dry sand, earth, vermiculite), and place in a chemical waste container; use water spray to cool and disperse vapors, and dilute spills to form nonflammable mixtures.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent and place in a sanitary landfill; whatever cannot be saved for recovery or recycling may be sent to a RCRA approved incinerator or disposed of in a RCRA approved waste facility; store in a cool, dry, well-ventilated location; outside storage is preferred; inside storage should be in a standard flammable liquids storage room or cabinet; separate from strong bases, oxidants, food and feed-stuffs.

**REGULATORY INFORMATION:** CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a solvent for cellulose acetate and ethylcellulose; used in the manufacture of ethylene oxide and ethylene glycol; applications include introduction of hydroxyethyl group in organic synthesis and activation of sprouting in dormant potatoes.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 14.

### **ETHYLENEDIAMINE (NH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>, 60.12)**

**CAS/DOT IDENTIFICATION #:** 107-15-3/UN1604

**SYNONYMS:** 1,2-diaminoethane, dimethylenediamine, 1,2-ethanediamine, 1,2-ethylenediamine.

**PHYSICAL PROPERTIES :** colorless, clear, thick liquid; strongly alkaline, hygroscopic liquid; ammonia-like odor; solid below 47°F; freely soluble in water forming a hydrate; soluble in all proportions in ethyl alcohol; slightly soluble in ether; soluble in benzene unless insufficiently dried; MP (9°C, 47°F); BP (115°C, 239°F); DN (0.898 g/mL at 25°C); LSG (0.90); VS (0.0154 poise at 25°C); CP (172.6 J/K-mol liquid at 25°C); HV (44.98 kJ/mol at 25°C); VD (2.07); VP (10.7 mmHg at 20°C); OT (1.0 ppm in air, 16,000 mg/L in water).

**CHEMICAL PROPERTIES:** combustible liquid; corrosive to metals; volatile with steam; strongly alkaline; may readily absorb carbon dioxide from air to form a nonvolatile carbonate; reactions with acetic acid, nitric acid, sulfuric acid, acrylonitrile, oleum, and other selected acids and unsaturated compounds caused the temperature and pressure in a closed container to rise; reacts vigorously with oxidizing materials, chlorine, hypochlorite, halogenated compounds, and reactive organic compounds; FP (43°C, 110°F); LFL/UFL (2.5%, 12% at 212°F); AT (385°C, 725°F); HC (-452.6 kcal/gmol at 25°C); HF (-63.0 kJ/mol liquid at 25°C); H<sub>f</sub> (22.6 kJ/mol at 284.2K).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 3, Flammability 2, Reactivity 0; flammable liquid when exposed to heat, flame or oxidizers; reacts violently with acetic acid, acetic anhydride, acrylic acid, acrylonitrile, allyl chloride, carbon disulfide, chlorosulfonic acid, hydrochloric acid, nitric acid, sulfuric acid, ethylene chlorohydrin, oleum, acrolein, or vinyl acetate; heating to decomposition emits carbon monoxide, carbon dioxide, hydrocarbons, toxic oxides of nitrogen, and toxic amine vapors; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat); skin contact (severe eye and skin burns, respiratory distress, skin sensitization, allergic reaction).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with copious amounts of flowing water, then wash with soap and water; provide oxygen or respiratory support; if ingested, drink large amounts of water or milk and induce vomiting.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 200ppm; toxic effect: peripheral nervous system.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; nasal irritation; severe eye and skin burns.

**CHRONIC HEALTH RISKS:** severe allergic reactions; respiratory distress; sensitization dermatitis; asthma; liver and kidney damage; may alter genetic material; may cause reproductive effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm; OSHA PEL TWA 10 ppm (25 mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (25 mg/m<sup>3</sup>); IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear rubber overclothing; wear chemical resistant rubber gloves; safety goggles are recommended; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; absorb small quantities of liquid on paper towels and evaporate in a fume hood; absorb large quantities of liquid in noncombustible material and atomize in a suitable combustion chamber equipped with effluent gas cleaning device; allow solid form to melt and properly dispose of liquid.

**DISPOSAL AND STORAGE METHODS:** add a layer of sodium bisulfate; spray with water, neutralize and route to sewage plant; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location; outside storage is preferred; separate from oxidizing materials, acids, and sources of halogens.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sf1; Sf2; CW1; CW2; A1; CAL; DOT hazard class/division (8); labels (corrosive, flammable liquid).

**OTHER COMMENTS:** used as a solvent for casein, albumin, shellac, and sulfur; used in the manufacture of surfactants, emulsifying agents, wetting agents, dispersants, corrosion inhibitors, detergents, and textile surface treatments; used in preparation of dyes, synthetic waxes, resins, insecticides, and asphalt wetting agents; also used as an inhibitor in antifreeze solutions; has been used as a pharmaceutical aid.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14.

## **ETHYLENE DIBROMIDE (C<sub>2</sub>H<sub>4</sub>Br<sub>2</sub>, 187.88)**

**CAS/DOT IDENTIFICATION #:** 106-93-4/UN1605

**SYNONYMS:** 1,2-dibromoethane, ethylene bromide, glycol dibromide.

**PHYSICAL PROPERTIES :** colorless, heavy liquid; pleasant, chloroform-like odor; miscible with alcohol and ether; practically insoluble in water; MP (10°C, 50°F); BP (131-132°C, 268-270°F); DN (2.718 g/mL at 20°C); LSG (2.18); ST (38.75 dynes/cm, 0.03875 N/m at 20°C); VS (1.727 cP at 20°C); HV (82.1 Btu/lb, 45.6 cal/g); VD (6.48); VP (12 mmHg at 25°C, 17.4 mmHg at 30°C).

**CHEMICAL PROPERTIES:** noncombustible liquid; reacts with chemically-active metals such as sodium, potassium, calcium, hot aluminum, and magnesium; may also react with strong oxidizers and liquid ammonia; FP (none); LFL/UFL (none); AT (none); HC (1289 cal/g, 6647 J/g).

**EXPLOSION and FIRE CONCERNS:** not combustible; if involved in a fire, decomposes to produce hydrogen bromide; NFPA rating Health 3, Flammability 0, Reactivity 0; incompatible with oxidizing materials; alkali metals and ammonia; use carbon dioxide, dry chemical or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (dermatitis, burning sensation, headache, nausea).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** skin-human 1538 mg/24H; toxic effect: severe irritation; inhalation-man TCLo 88ppb/8H; toxic effect: reproductive effects; oral-woman LDLo 90mg/kg; toxic effect: gastrointestinal tract, systemic effect; LD50 (man) 65 mg/kg; EPA Cancer Risk Level  $5 \times 10^6$  mg/m<sup>3</sup>; inhalation unit risk estimate  $2.2 \times 10^{-4}$  µg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory tract; labored breath; wheezing; laryngitis; headache; nausea; vomiting; gastrointestinal disturbances; kidney and liver damage; cardiac effects; damage to the spleen; allergic reactions; burning sensation.

**CHRONIC HEALTH RISKS:** genetic alterations; dermatitis with vesiculation; reproductive effects; carcinogenic effects; target organs: liver, kidney, lungs, and eyes.

**EXPOSURE GUIDELINES:** ACGIH TLV suspected human carcinogen; OSHA PEL TWA 20 ppm; CL 30 ppm; Pk 50 ppm/5M/8H; NIOSH REL TWA 0.045 ppm; IDLH 100ppm.

**PERSONAL PROTECTION:** wear protective clothing, chemical-resistant gloves, and chemical safety goggles; wear a face shield and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use an appropriate foam to blanket release and suppress vapors; absorb as much as possible in noncombustible materials such as dry earth, sand, or vermiculite; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; store in a cool, dry, well-ventilated location; isolate from oxidizing materials, alkali metals, and ammonia; do not use handling equipment or containers composed of magnesium or aluminum or their alloys.

**REGULATORY INFORMATION:** CA2; S1; S24; S32; S50-a; S61; S62; R2; R3; R4; R7; R8; U waste #; (U067); Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; CW1; CW2; A2; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of dyes, resins, grignard reagents, and pharmaceuticals; used in the synthesis of vinyl bromide and ethylene; used as a component of anti-knock gasolines; used as a fumigant.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14.

**ETHYLENE DICHLORIDE (C<sub>2</sub>H<sub>4</sub>Cl<sub>2</sub>, 98.96)****CAS/DOT IDENTIFICATION #:** 107-06-2/UN1184**SYNONYMS:** 1,2-dichloroethane, ethylene chloride, glycol dichloride.

**PHYSICAL PROPERTIES :** colorless, clear liquid; pleasant chloroform-like odor; sweet taste; burns with smoky flame; miscible with alcohol, chloroform and ether; soluble in acetone and carbon tetrachloride; slightly soluble in water; MP (-35°C, -32°F); BP (83-84°C, 181-182°F); DN (1.257 g/mL at 20°C); LSG (1.26); ST (31.86 mN/m at 25°C); VS (0.779 mPa-s at 25°C); CP (128.4 J/K-mol at 25°C); HV (76.4 cal/g); VD (3.35); VP (100 mmHg at 29.4°C); OT (6-40 ppm).

**CHEMICAL PROPERTIES:** combustible; reacts with strong oxidizers, caustics, and liquid ammonia; can also react with magnesium, aluminum powder, sodium, and potassium; decomposes to vinyl chloride and hydrogen chloride above 1112°F; corrodes iron and other metals at elevated temperatures when in contact with water; FP (13°C, 56°F); LFL/UFL (6.2%, 15.9%); AT (413°C, 775°F); HF (-167.4 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; dangerous fire hazard if exposed to heat, flame, or oxidizers; vapors are heavier than air and may travel to an ignition source and flash back; reacts violently with aluminum, nitrogen tetroxide, dimethylaminopropylamine, or liquid ammonia; reacts vigorously with propylene dichloride and orthodichlorobenzene; vigorous reaction with oxidizing materials can emit vinyl chloride and hydrogen chloride; incompatible with alkalis, amines, and alkali metals; combustion by-products include hydrogen chloride and phosgene; forms dense soot; use dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin); skin absorption (headache, nausea, respiratory system).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCl<sub>o</sub> 4000 ppm/H; toxic effect: central nervous system, peripheral nervous system, gastrointestinal tract; oral-human LDLo 286 mg/kg; toxic effect: gastrointestinal tract; oral-human TDLo 428 mg/kg; toxic effect: gastrointestinal tract, central nervous system, pulmonary system; oral-man TDLo 892mg/kg; toxic effect: central nervous system, cardiovascular effects, pulmonary system; msc-human lymphocyte 100mg/L.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and mucous membranes; headache; nausea; vomiting; liver and kidney damage; corneal opacity; central nervous system depression.

**CHRONIC HEALTH RISKS:** may alter genetic material; tremors; low blood sugar levels; appetite loss; nausea; vomiting; dermatitis; cardiovascular damage; carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (40mg/m<sup>3</sup>); OSHA PEL TWA 1 ppm; OSHA PEL STEL 2 ppm; NIOSH REL TWA 1 ppm; NIOSH REL CL 2ppm/15M; IDLH 50 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, chemical-resistant gloves and chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use appropriate foam to blanket release and suppress vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in a sanitary landfill; store in a cool, dry location; storage should be away from heat, sparks, and open flame.

**REGULATORY INFORMATION:** CA2; R4; U waste #; (U077); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; CW1; CW2; A2; CAL; DOT hazard class/division (3); labels (flammable liquid, poison).

**OTHER COMMENTS:** used as a solvent for fats, oils, waxes, gums, resins, and particularly for rubber; used in the manufacture of acetyl cellulose, tobacco extract, pharmaceutical products, acrylic adhesives, and rubber cement.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 13; 14.

### ETHYLENE GLYCOL DINITRATE ( $O_2NOCH_2CH_2ONO_2$ , 152.08)

**CAS/DOT IDENTIFICATION #:** 628-96-6/none

**SYNONYMS:** egdn, 1,2-ethanediol dinitrate, ethylene dinitrate, ethylene nitrate, glycol dinitrate, nitroglycol.

**PHYSICAL PROPERTIES :** colorless to yellowish, oily liquid; odorless; sweetish taste; poor solubility in water; very soluble in alcohol and ether; MP(  $<-22^\circ C$ ,  $< -7.6^\circ F$ ); BP( $>197.2^\circ C$ ,  $>387^\circ F$  at 760 mmHg); DN(1.490 g/cm<sup>3</sup> at 20°C); LSG (1.49); VD (5.25); REL DN vapor/air mixture (1.000 at 20°C); VP(0.05 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with acids and alkalis; FP (215°C, 419°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible and explosive liquid; heating may cause violent combustion or explosion, producing toxic fumes of oxides of nitrogen; explodes at 114°C (237°F); may decompose explosively on shock, friction, or concussion; incompatible with acids and bases; in case of fire, evacuate area and fight fires only from an explosion-resistant location; use powder, water spray, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, nausea, weakness); skin absorption (lowered blood pressure, flushing palpitations, delirium, headache, dizziness); contact (angina, central nervous system depression, skin irritation due to direct contact); ingestion (abdominal pain, nausea, vomiting, formation of methemoglobin).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; give artificial respiration if indicated; in case of ingestion, rinse mouth and get medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** throbbing headache; dizziness; flushing; palpitations; delirium; hypotension (lowered blood pressure); weakness; abdominal pain; nausea; vomiting; depression of central nervous system; methemoglobinemia; angina; may cause skin irritation; may result in death.

**CHRONIC HEALTH RISKS:** may have effects on cardiovascular system; anemia, liver damage, and damage to kidneys have been reported in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05 ppm (0.31/m<sup>3</sup>); OSHA PEL CL 0.2 ppm(1mg/m<sup>3</sup>)(skin); NIOSH REL STEL 0.1mg/m<sup>3</sup> (skin); IDLH 75 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; use chemical safety goggles or face shield; a system of local exhaust ventilation or breathing protection is recommended; use non-sparking hand-tools; build-up of electrostatic charges can be prevented by grounding; for extra personal protection, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** evacuate danger area; collect spilled liquid in sealable containers or absorb with noncombustible materials (e.g., dry earth, sand or vermiculite); flush remaining spill with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool dry location; use only with adequate ventilation; storage should be in a separate building; keep containers tightly closed; bond and ground containers to prevent build-up of electrostatic charges when transferring liquid; separate from acids; keep away from any area where the fire hazard may be acute; do not expose to shock or friction.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (forbidden).

**OTHER COMMENTS:** used as an explosive for mining and fuel industries; useful in detecting hidden bombs by analyzing ambient air for ethylene glycol dinitrate; use as an additive to dynamite.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### **ETHYLENEIMINE (C<sub>2</sub>H<sub>5</sub>N, 43.08)**

**CAS/DOT IDENTIFICATION #:** 151-56-4/UN1185

**SYNONYMS:** aminoethylene, azirane, aziridine, dimethyleneimine, dimethylenimine, ethylenimine.

**PHYSICAL PROPERTIES :** oily, water-white liquid; ammonia-like odor; soluble in ethanol; miscible in water; MP (-72°C, -98°F); BP (57°C, 135°F); DN (0.832 g/cm<sup>3</sup> at 20°C); LSG (0.83); ST (34.5 dynes/cm at 20°C); HV (333 Btu/lb, -8850 cal/g); VD (1.48); VP (160 mmHg at 20°C); OT (1.5 ppm).

**CHEMICAL PROPERTIES:** very corrosive; may polymerize explosively in the presence of acids; polymerization may be caused by elevated temperature, sunlight, oxidizers, or peroxides; uninhibited monomer vapor may form polymer in confined spaces; usually contains inhibitors to prevent polymerization; may react with acids, silver, and chlorinating agents; FP (-11°C, 12°F); LFL/UFL (3.3%, 54.8%); AT (320°C, 608°F); HC (-15,930 Btu/lb, -8850 cal/g); HF (91.9 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 4, Flammability 3, Reactivity 3; vapors are heavier than air and may travel to an ignition source and flashback; dangerous fire and explosion hazard when exposed to heat, flame or oxidizers; violent reaction with acids, aluminum chloride and substituted anilines, acetic acids, acetic anhydride, acrolein, acrylic acid, allyl chloride, chlorosulfonic acid, epichlorohydrin, hydrogen

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chloride, hydrogen fluoride, nitric acid, oleum, sulfuric acid, vinyl acetate, carbon disulfide, chlorine, silver, glyoxal, and  $\beta$ -propiolactone; reacts with chlorinating agents to form explosive 1-chloroaziridine; explosive reaction with silver or its alloys to form silver derivatives; violent exothermic reaction in the presence of catalytically active metals or chloride ions; closed containers may rupture violently when heated; combustion by-products include oxides of nitrogen; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose); skin absorption (nausea, vomiting, headache, irritates upper respiratory tract).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** cyt-human lung  $1\ \mu\text{mol/L}$ .

**ACUTE HEALTH RISKS:** irritation of eyes, skin, nose and throat; nausea; vomiting; headache; dizziness; pulmonary edema; liver and kidney damage.

**CHRONIC HEALTH RISKS:** severe eye burns; skin sensitization; edema of the lungs; mutation of the trachea and bronchi; secondary bronchial pneumonia; genetic effects; neoplastic effects; deep necrosis; carcinogenic.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (skin); OSHA PEL TWA 1  $\text{mg/m}^3$  (skin); OSHA TLV TWA 0.5 ppm ( $0.88\ \text{mg/m}^3$ ); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; absorb as much as possible in noncombustible materials such as dry earth, sand, or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in a sanitary landfill; store in a cool, dry, well-ventilated place; do not use handling equipment or containers composed of magnesium, aluminum or their alloys; store away from heat, sunlight, and oxidizing materials; isolate from strong oxidizers and peroxides.

**REGULATORY INFORMATION:** CA2; R4; R7; R8; P waste #; (P054); Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; Sf2; Sf3; A1; A4; CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid).

**OTHER COMMENTS:** used in the manufacture of triethylenemelamine, taurine, and fuel oil; used in the manufacturing of adhesives, binders, cosmetics, pharmaceuticals, insect repellants, and ion exchange resins.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14.

### ETHYLENE OXIDE( $\text{C}_2\text{H}_4\text{O}$ , 44.06)

**CAS/DOT IDENTIFICATION #:** 75-21-8/UN1040

**SYNONYMS:** dimethylene oxide, 1,2-epoxyethane, ethene oxide, oxirane.

**PHYSICAL PROPERTIES :** colorless gas at room temperature; sweet, ether-like odor; liquid below  $12^\circ\text{C}$ ; miscible in water and alcohol; very soluble in ether; MP ( $-112^\circ\text{C}$ , -

170°F); BP (11°C, 51°F); DN (0.8711 g/mL at 20°C); SG (0.89 at 0°C); HV (24.75 kJ/mol at 25°C); VD (1.52); VP (1095 mmHg at 20°C); OT (430 ppm).

**CHEMICAL PROPERTIES:** highly reactive; hazardous polymerization may occur; reacts with acids, alkalis, strong oxidizers, chlorides of iron, oxides of iron and aluminum, aluminum and tin; may also undergo runaway reaction with water; FP (-20°C, -4°F); LFL/UFL (3%, 100%); AT (429°C, 804°F); HF (-52.6 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable gas; NFPA rating Health 3, Flammability 4, Reactivity 3; volatile flammable liquid below room temperature; polymerizes violently on contact with ammonia, alkali hydroxides, amines, metallic potassium, acids, aluminum chloride, iron (III) chloride, tin (IV) chloride, aluminum oxide, iron oxide, and rust; reacts explosively with glycerol at 200°C; vapor forms explosive mixtures with air; vapors may travel to an ignition source and flash back; incompatible with bases, alcohols, air, copper, trimethyl amine, magnesium perchlorate, mercaptans, alkane thiols, bromoethane, and others; explosive decomposition may occur in vapor or liquid phases; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, mucous membranes, and upper respiratory tract); skin absorption (allergic skin reaction, severe irritation, burning sensation).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with copious amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human T<sub>CLo</sub> 12,500 ppm/10S; toxic effect: nose; inhalation-woman T<sub>CLo</sub> 500 ppm/2M; toxic effect: central nervous system, gastrointestinal tract, pulmonary system; skin-human 1%/7S; dns-human leukocyte 4mmol/L; sce-human lymphocyte 4 pph; sce-human lymphocyte 10mg/L.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; headache; nausea; vomiting; diarrhea; breathing difficulty; cyanosis; pulmonary edema; drowsiness; weakness; incoordination; EKG abnormalities; burns to eyes and skin; frostbite; peculiar taste.

**CHRONIC HEALTH RISKS:** may alter genetic material; reproductive disorders; carcinogen; target organs: eyes, skin, respiratory system, liver, blood, kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm suspected human carcinogen; OSHA PEL TWA 1 ppm cancer hazard; NIOSH REL TWA < 0.1 ppm (< 0.18 mg/m<sup>3</sup>); NIOSH REL CL 5 ppm/10M/D (9 mg/m<sup>3</sup>); NIOSH PEL < 0.2 mg/m<sup>3</sup>; IDLH 800 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; dilution required in enclosed areas such as sewers to eliminate flash potential; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** flush with large amounts of water into confined spaces such as sewers; dilute to 1 part in 100 parts water to eliminate flash potential; store in a cool, dry location away from heat, oxidizing materials, and sunlight; isolate from strong acids, bases, salts, and combustible materials; outside storage preferred.

**REGULATORY INFORMATION:** CA2; F2; F7; R4; R7; R8; U waste #; (U115); Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf2; Sf3; A1; A4; A5; DOT hazard class/division (2.3); labels (flammable gas, poison gas).

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**OTHER COMMENTS:** used as the starting material for the manufacture of acrylonitrile and nonionic surfactants; used in the production of ethylene glycol; used as a fumigant for food-stuffs and textiles; used in the sterilization of surgical instruments.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 13; 14.

### N-ETHYLMORPHOLINE (C<sub>4</sub>H<sub>8</sub>ONCH<sub>2</sub>CH<sub>3</sub>, 115.18)

**CAS/DOT IDENTIFICATION #:** 100-74-3/none

**SYNONYMS:** 4-ethylmorpholine, nem.

**PHYSICAL PROPERTIES:** colorless liquid; ammonia-like odor; soluble in all proportions in water, ethanol and ether; soluble in acetone; MP (-62.78°C, -81°F); BP (138-139°C, 280-282°F at 763 mmHg); DN (0.8996 g/mL liquid at 20°C); BULK DN (7.6 lb/gal at 20°C); LSG (0.90 at 20°C); VS (1.08 mPa-s at 20°C); HV (36.94 kJ/mol at 101.3 KPa); VD (4.0); VP (6.1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with oxidizing materials; will attack some forms of plastics, rubber, and coatings; FP (32°C, 90°F); LFL/UFL (1.0%, 9.8%); AT (data not found in literature); pKa (7.67); IR (1.4400 at 20°C); NMR (202).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; a dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 0; explosive vapor/air mixture may be formed above the flash point; contact with strong acids will cause violent spattering; reacts violently with strong oxidizers, causing fires and explosions; toxic gases and vapors (such as carbon monoxide and oxides of nitrogen) may be released in a fire; use alcohol-resistant foam, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, labored breathing, shortness of breath, sore throat, irritates respiratory system); skin absorption (transient corneal edema, temporary foggy vision with halos around lights); contact (skin burns, redness, pain); ingestion (cough, abdominal pain, vomiting, diarrhea).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of water; provide oxygen if breathing is difficult; administer artificial respiration if breathing has stopped; in case of ingestion, rinse mouth and give large amounts of water to drink; seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes, nose, and throat; olfactory fatigue; corneal edema; distortion of vision; blue-gray vision; optical halos; drowsiness; cough; labored breathing; shortness of breath; abdominal pain; vomiting; diarrhea; may cause severe sore throat and redness of mucous membranes; exposure to high concentration may result in death.

**CHRONIC HEALTH RISKS:** abnormalities in vision, upper respiratory irritation, dermatitis, and pulmonary abnormalities have been observed in industry but no chronic effects have been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (24 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 200 ppm (94 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 5 ppm (23 mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, nitrile gloves, lab coat, apron or protective suit; wear splash-proof safety goggles and face shield; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear any self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; cover large spills with 9:1 mixture of sand and soda ash; cautiously ignite in a open furnace equipped with afterburner and scrubber; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** large quantities can be atomized in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; liquid may also be absorbed in sand or inert absorbent, and properly disposed of in a secured, sanitary, land-fill; store in a cool, dry location; use only with adequate ventilation; storage should be in a detached storehouse without any ignition sources; separate from strong oxidants and strong acids.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (no data found in literature); labels (no data found in literature).

**OTHER COMMENTS:** used as a chemical intermediate for pharmaceuticals, dyestuffs, emulsifying agents, and rubber accelerators; utilized as a solvent for dyes, resins, and oils; commonly used substrate for enzyme reactions.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 15; 16.

### **FERBAM (C<sub>9</sub>H<sub>18</sub>FeN<sub>3</sub>S<sub>6</sub>, 416.51)**

**CAS/DOT IDENTIFICATION #:** 14484-64-1/UN2771

**SYNONYMS:** carbamate, dimethylcarbamodithioic acid, iron complex, ferric dimethyldithiocarbamate, iron dimethyldithiocarbamate, iron tris (dimethyldithiocarbamate), karbam black®.

**PHYSICAL PROPERTIES:** dark brown to black solid or powder; odorless; slightly soluble in water; soluble in chloroform, acetone, pyridine, and acetonitrile; MP (>180°C, >356°F)(decomposes); BP (decomposes); DN/SG (unknown); VD (NA); pH (5.0); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; tends to decompose on prolonged storage or on contact with moisture; reacts with strong oxidants; hydrolyzed by alkali; unstable to lime; non-corrosive; intense mass spectral peaks; readily dispersible; decomposes above 180°C (356°F); FP (unknown); LFL/UFL (unknown); AT (unknown); HC (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating (not rated); incompatible with strong oxidants, copper, or mercury compounds; decomposes on exposure to heat and moisture, producing toxic and flammable gases; should be kept away from ignition sources because decomposition products are flammable; minimum explosive concentration (MEC) is 55 g/m<sup>3</sup>; hazardous decomposition products include toxic fumes of oxides of nitrogen and sulfur oxides; use water spray or dry powder for firefighting purposes.

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**HEALTH SYMPTOMS:** inhalation (cough, sore throat, headache, irritates eyes, skin and respiratory tract); skin contact (dry skin, skin sensitization, contact dermatitis); ingestion (headache, confusion, drowsiness, nausea, vomiting, diarrhea, weight loss).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; provide oxygen if breathing is difficult; administer artificial respiration if breathing has stopped; in case of ingestion, induce vomiting; seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes, skin and respiratory system; irritation to tissues of mucous membranes; cough; sore throat; headache; drowsiness; confusion; nausea; vomiting; diarrhea; weight loss; ataxia; lethargy; reduction in blood pressure; suppression of tendon reflexes; respiratory paralysis and death.

**CHRONIC HEALTH RISKS:** repeated or prolonged skin contact may cause dermatitis and skin sensitization; may cause renal damage; high doses may affect the nervous system and thyroid; may also have the potential for causing damage to the developing fetus; has been reported to cause cancer in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>; NIOSH REL TWA 10 mg/m<sup>3</sup>/10H; IDLH 800 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear personal protective clothing, including waterproof boots, rubber gloves, long-sleeved shirt, long pants and hat; use dust-proof safety goggles; appropriate respirators with high-efficiency particulate filters are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or IDLH conditions; a closed system of local exhaust ventilation is recommended at the site of chemical release; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep spilled substance into sealable containers for disposal in a secured, sanitary landfill; use a vacuum or a wet method to reduce dust during clean-up; absorb liquid containing ferbam with inert materials (e.g., dry earth, sand or vermiculite), and place in a chemical waste container; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in a secured, sanitary landfill; large amounts should be incinerated in a unit with effluent gas scrubbing device; store in a cool, dry, well-ventilated, secure area; stable to storage in closed containers; separate from strong oxidants, alkaline materials, and copper or mercury containing compounds; avoid exposure to heat and moisture.

**REGULATORY INFORMATION:** F2; F3; R4; U waste # (U396); Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; Sf3; A1; CAL; DOT hazard class/division (6.1).

**OTHER COMMENTS:** used as a fungicide on fruit, nuts, vegetables, ornamental crops, and in household applications; mainly used for protection of foliage against fungal pathogens.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 15; 16.

**FERROVANADIUM DUST (FeV, 106.8)**

**CAS/DOT IDENTIFICATION #:** 12604-58-9/none

**SYNONYMS:** O,O-diethyl-O-4-(methylsulfinyl)phenyl phosphorothioate, ferrovanadium, terracur<sup>®</sup>p.

**PHYSICAL PROPERTIES:** dark, solid particles dispersed in air; odorless; an iron-vanadium alloy, containing 50-80% vanadium, depending on the grade; available in various lump, crushed, and ground sizes; insoluble in water; greater solubility in biological fluids than free vanadium; MP (1480-1520°C, 2696-2768°F); BP (NA); DN/SG (unknown, but >1); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with strong oxidizers; no hazardous decomposition products have been reported; FP (NA); LFL/UFL (NA); AT (400°C, 752°F(layer), 440°C, 824°F(cloud)).

**EXPLOSION and FIRE CONCERNS:** metal is a noncombustible solid, but dust may be an explosion hazard; NFPA rating (not rated); contact with strong oxidizers may cause fires and explosions; minimum explosive concentration is 1.3 g/m<sup>3</sup>; use dry sand, dry dolomite, or dry graphite powder for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, and throat); contact (chronic bronchitis and pneumonitis in animals).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; provide oxygen if breathing is difficult; administer artificial respiration if breathing has stopped; in case of ingestion, induce vomiting; seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** mild eye and respiratory system (nose and throat) irritation; may cause respiratory impairment; has been reported to cause asthmatic-like symptoms.

**CHRONIC HEALTH RISKS:** systemic effects have not been reported from industrial exposure; animals exposed for one hour on alternate days for two months at very high concentrations (1000 to 2000 mg/m<sup>3</sup>) developed chronic bronchitis and perialveolitis (i.e., chronic inflammation of the lungs).

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg/m<sup>3</sup>; ACGIH TLV STEL 3 mg/m<sup>3</sup>; OSHA PEL TWA 1 mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; NIOSH REL STEL 3 mg/m<sup>3</sup>; IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear personal protective clothing, including waterproof boots, rubber gloves, long-sleeved shirt, long pants and hat; use dust-proof safety goggles; appropriate respirators with high-efficiency particulate filters are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or IDLH conditions; a closed system of local exhaust ventilation is recommended at the site of chemical release; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of release to disperse dust; cautiously collect released material and deposit in sealed containers for proper disposal; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in a secured, sanitary landfill; store in a cool, dry, well-ventilated area; storage should be in tightly closed containers;

protect against physical damage; separate from strong oxidizers; avoid sparks, flame, and other sources of heat.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (no data found in literature); label (no information found).

**OTHER COMMENTS:** used in the preparation of steel containing vanadium; added to steel to produce fineness of grain, toughness, and resistance to high temperature and torsion.

**KEY REFERENCES:** 4; 5; 6; 7; 16; 18.

**FLUORIDES** (Molecular formula and formula weight vary depending upon specific compounds).

**CAS/DOT IDENTIFICATION #:** none/none

**SYNONYMS:** synonyms may vary depending upon specific compound; (note: perfluorides is a commonly used name).

**PHYSICAL PROPERTIES:** Appearance and odor vary depending upon specific compounds. The term fluorides will be used to refer to the common salts of the element fluorine. Inorganic fluorides are always found combined with other materials and are solids at room temperature. Examples of fluorides include sodium fluoride and calcium fluoride. Sodium Fluoride and Calcium Fluoride are white solids. Sodium fluoride dissolves easily in water, but is sparingly soluble in ethanol. Calcium fluoride is insoluble or sparingly soluble in water, is soluble in acids, and insoluble in acetone. Other physical properties are as follows. (sodium fluoride (NaF)) MP(992°C, 1818°F); BP(1702°C, 3096°F); DN(2 g/cm<sup>3</sup> at 41°C); SG (2.8 at 20°C); CP(46.9 J/K-mol crystal at 25°C); VD(not applicable); VP(1 mmHg at 1077°C). (calcium fluoride (CaF<sub>2</sub>)) MP(1418°C, 2584°F); BP(2500°C, 4532°F approximately); DN(3.180 g/cm<sup>3</sup>); CP(67.0 J/K-mol crystal at 25°C); VD(not applicable); VP(approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** generally stable under ordinary conditions of use and storage; calcium fluoride can react with hot concentrated sulfuric acid to liberate hydrogen fluoride; fluorocarbons are chemically inert to most materials; fluoroamides can react with lithium tetrahydroaluminate and with sodium at very high temperatures; some fluorinated cyclopropenyl methyl ethers react with water or methanol FP(NA); LFL/UFL (NA); AT (NA); HC(NA).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating (not rated); poisonous gases are produced in fire; containers may explode in fire; contact with strong acids (such as hydrochloric and sulfuric acid) will result in violent reactions; form explosive gases on contact with nitric acid; some fluorodinitro compounds of methane and ethane are sensitive explosives; fluorocarbons can react violently with barium, sodium, and potassium; violent reactions will occur when some fluorinated cyclopropenyl methyl ethers contact water or methanol; when heated to decomposition, or on contact with acid or acid fumes, they emit highly toxic fumes of F<sup>-</sup>; water should not be used for firefighting purposes; all other extinguishing agents are suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates nose and throat, irritates lungs, build-up of fluid in lungs, nausea, headache, nosebleeds); contact (irritates and may damage eyes, irritates skin causing a rash or burning feeling, dental defects); ingestion (nausea, vomiting, diarrhea, abdominal burning, cramp-like pains).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, give oxygen; begin rescue breathing if breathing has stopped; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** (Note: Toxicity data for sodium fluoride (NaF) will be used for illustrative purposes). Oral human LDLo 71 mg/kg; toxic effect: central nervous system, musculo-skeletal effects, such as osteoporosis and muscular degeneration; intradermal-human TDLo 14µg/kg; toxic effect: peripheral nervous system effects, mucous membrane effects; oral-man TDLo 1662 mg/kg; toxic effect: cardiovascular system, pulmonary effects, gastrointestinal tract; oral-woman LDLo 90 mg/kg; oral-woman LDLo 360 mg/kg; toxic effect: pulmonary effects, gastrointestinal tract; oral-woman TDLo 7 mg/kg; toxic effect: eye, pulmonary effects; unreported-man LDLo 75 mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and throat; can also irritate the skin causing a rash or burning sensation; pulmonary edema; respiratory system irritation; severe nausea; headaches; nosebleeds; abdominal pain; diarrhea; excessive salivation; thirst; sweating; vomiting; weakness; convulsions; collapse; death.

**CHRONIC HEALTH RISKS:** repeated high exposures may affect kidneys; repeated exposure can cause nausea, vomiting, loss of appetite, diarrhea or constipation; nosebleeds and sinus problems can occur; can cause asthma attacks, severe bone changes, stiff spine, and calcification of ligaments of ribs and pelvis; signs of pulmonary fibrosis (lung scarring) have been noted; deposits of fluorides in the bones and teeth can cause a condition called "fluorosis", characterized by pain, disability, crippling skeletal abnormalities, and mottling of tooth enamel; loss of weight, anorexia, wasting and cachexia are among the common findings in chronic fluoride poisoning.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2.5 mg(F)/m<sup>3</sup>; OSHA PEL TWA 2.5 mg(F)/m<sup>3</sup>; NIOSH REL TWA (2.5 mg/m<sup>3</sup>); IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear dust proof safety goggles when working with powders or dust; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; if the possibility of exposures above 500 mg/m<sup>3</sup> exists, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; collect powdered material and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; liquid containing fluoride should be absorbed with inert materials, such as dry earth, sand, or vermiculite.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in sealable containers in a secured, sanitary landfill; store in tightly closed containers in a cool, well-ventilated area; must be stored to avoid contact with strong acids (such as hydrochloric, sulfuric and nitric); keep away from water.

**REGULATORY INFORMATION:** A1; A2; DOT classification (none).

**OTHER COMMENTS:** Sodium chloride is used as a preservative, insecticide, fungicide, rodenticide and additive to drinking water; has also been employed in electroplating, glass, enamels, and as windows for ultraviolet and infrared radiation instruments; calcium fluoride is used in chemical industry as a source of hydrogen fluoride (HF), as well as being used in lasers, ceramics, fluxes, electronics, and lubricants; copper fluoride is employed in high energy batter-

ies; stannous fluoride is used as a toothpaste additive; uranium hexafluoride is utilized in the enrichment of uranium; zinc fluoride is used in impregnating lumber.

**KEY REFERENCES:** 4; 5; 6; 15; 16; 18.

## FLUORINE (F<sub>2</sub>, 38.00)

**CAS/DOT IDENTIFICATION #:** 7782-41-4/UN1045

**SYNONYMS:** fluorine-19, fluorine, compressed.

**PHYSICAL PROPERTIES :** pale-yellow to greenish gas; turns white at -2°C; strong, choking, intense odor; MP (-219°C, -363°F); BP (-188°C, -307°F); DN (1.5127 g/mL liquid at -188.13°C); LSG (1.69); VS (23.7 μPa-s gas at 25°C); CP (31.3 J/K-mol gas at 25°C); LHV (71.6 Btu/lb, 39.8 cal/g, 1.67 x 10<sup>5</sup> J/kg); VD (1.31); VP (1 mmHg at -223°C, 10 mmHg at -214.1°C); OT (0.035 ppm).

**CHEMICAL PROPERTIES:** most reactive nonmetal; corrosive gas; extremely strong oxidizer; higher oxidation potential than ozone; most electronegative element; weaker bonding than bonding in chlorine and bromine; reacts vigorously with most oxidizable substances at room temperature; reacts to form fluorides with all the elements except helium, neon, and argon; reacts with all materials except for some metals and some Teflons at low temperatures; water reactive; reaction with water forms hydrogen fluoride and oxygen; reacts with metal hydroxides at low temperatures to yield metal fluorides, water, oxygen and oxygen fluoride; decomposes in water, yielding hydrofluoric acid, oxygen fluoride, hydrogen peroxide, oxygen and ozone; FP (NA); LFL/UFL (NA); AT (NA); DE (37.7 kcal).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; will cause fire and react violently with combustibles; NFPA rating Health 4, Flammability 0, Reactivity 4; reacts with nitric acid, forming the explosive gas, fluorine nitrate; reacts violently with organic compounds, usually with disintegration of the molecule; solid fluorine explodes on contact with liquid hydrogen; explosive reaction with ammonia, cesium fluoride and fluorocarboxylic acids, graphite, carbon tetrachloride, chloroform, iodoform, hydrogen, nitric acid, silver cyanide, sulfur dioxide, carbon monoxide, sodium acetate, sodium bromate, stainless steel, and water; ignites on contact with acetylene, ceramic materials, halogens, metal hydrides, metal iodides, metal salts, and metal silicides; violent reaction on contact with nonmetals, such as boron, yellow or red phosphorus, selenium, tellurium, silicon, carbon, charcoal, and sulfur; reacts with water or steam to produce heat and toxic and corrosive fumes; closed containers may rupture violently when heated; use water spray or other agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, and mucous membranes); skin contact (highly caustic irritant to skin and tissues); ingestion (mottled teeth, osteosclerosis, and calcification of ligaments).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with large amounts of water; provide oxygen or artificial respiration.

**HUMAN TOXICITY DATA:** eye-human 25 ppm/5M; toxic effect: mild; 115 ppm sublethal in drinking water; 180 ppm toxic in drinking water; 2,000 ppm lethal in drinking water; 500 mg/kg has been fatal to humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and respiratory tract; laryngeal spasms; bronchial spasms; pulmonary edema; eye and skin burns; respiratory paralysis.

**CHRONIC HEALTH RISKS:** mottled enamel of teeth; osteosclerosis; calcification of ligaments.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm; ACGIH TLV STEL 2 ppm; OSHA PEL TWA 0.1 ppm (0.2 mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.2 mg/m<sup>3</sup>); IDLH 25 ppm.

**PERSONAL PROTECTION:** full gas-tight protective clothing and self-contained breathing apparatus required; wear chemical resistant gloves; chemical safety goggles are also recommended.

**SPILL CLEAN-UP:** ventilate area of leak and disperse gas; stop flow of gas if possible; if leak cannot be stopped in place, allow to empty in a safe place in open air; keep water away from release.

**DISPOSAL AND STORAGE METHODS:** reduce by adding to concentrated solution of a bisulfite or a ferrous salt; acidify with sulfuric acid; add soda ash or dilute hydrochloric acid to neutralize and route to sewage plant; store in a cool, dry location; outside storage is preferred; isolate from all other storage.

**REGULATORY INFORMATION:** R4; R6; R8; P waste # (P056); Reportable Quantity (RQ): 10 lbs. (4.54 kg); Sf1; Sf2; Sf3; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, oxidizer).

**OTHER COMMENTS:** used in the manufacture of fluoro-chemicals and plastics; used as one component of liquid rocket fuel and in chemical lasers; chemical intermediate for sulfur hexafluoride, chlorine trifluoride, bromine trifluoride, uranium and molybdenum hexafluoride and oxygen difluoride.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14.

## FLUOROTRICHLOROMETHANE (CCl<sub>3</sub>F, 137.36)

**CAS/DOT IDENTIFICATION #:** 75-69-4/UN1017

**SYNONYMS:** freon<sup>®</sup>11, halocarbon<sup>®</sup>11, monofluorotrichloromethane, refrigerant<sup>®</sup>11, trichlorofluoromethane, trichloromonofluoromethane.

**PHYSICAL PROPERTIES :** colorless to water-white liquid at temperatures below 23.7°C (74.7°F); colorless gas above 75°F; faint ethereal odor; practically insoluble in water; soluble in alcohol, ether, and most organic solvents; gas is heavier than air and may accumulate in low ceiling spaces; MP (-111°C, -168°F); BP (24°C, 75°F); DN (1.494 g/mL at 17.2°C); LSG (1.49); CP (121.6 J/kmol liquid at 25°C); HV (25.02 kJ/mol at 25°C); VD (4.74); REL DN vapor/air mixture (4.4 at 20°C); VP (690 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; highly volatile liquid; reacts with aluminum, barium, or lithium; FP (NA); LFL/UFL (NA); AT (NA); HF (-301.3 kJ/mol liquid at 25°C); T<sub>c</sub> (198°C, 388°F); P<sub>c</sub> (43.2 atm, 635 psia).

**EXPLOSION and FIRE CONCERNS:** noncombustible liquid; nonflammable gas; NFPA rating (NA); reacts violently with metals and various powdered metals, such as aluminum, barium, calcium, magnesium and sodium; decomposes on contact with hot surfaces or flames forming corrosive and toxic fumes of hydrogen chloride, hydrogen fluoride, phosgene,

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and chlorine; in case of fire in the surroundings, all extinguishing agents allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, shortness of breath, drowsiness, confusion, scarring of lungs, unconsciousness); skin contact (liquid may cause frostbite); ingestion (irregular heartbeat, cardiac arrest, asphyxia).

**FIRST AID:** wash eyes immediately with large amounts of water; on frostbite, wash affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and provide oxygen; if not breathing, provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TDLo 50,000 ppm/30M; toxic effect: eye, pulmonary system, liver.

**ACUTE HEALTH RISKS:** confusion; drowsiness; shortness of breath; incoordination; tremors; could cause cardiac arrhythmias and asphyxiation; cardiac arrest; liquid may cause frostbite.

**CHRONIC HEALTH RISKS:** prolonged contact with skin may cause dermatitis; conjunctiva irritation; fibrosing alveolitis; liver changes.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm (5620 mg/m<sup>3</sup>); OSHA PEL TWA 1000 ppm (5600 mg/m<sup>3</sup>); NIOSH REL CL 1000 ppm (5600 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles; use a system of local exhaust ventilation to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; if in liquid form, allow to evaporate; never direct water jet on liquid; turn leaking cylinder with the leak up to prevent escape of gas in liquid state; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** if in liquid form, allow to evaporate; store in a cool, dry location; use only with adequate ventilation; maintain ventilation along the floor; separate from chemically-active metals, including sodium, potassium, calcium, granular barium, lithium shavings and various powdered metals; should not be used in the vicinity of a fire or a hot surface, or during welding.

**REGULATORY INFORMATION:** S10; R2; R3; R5; R6; R8; Reportable Quantity (RQ): 5000 lbs (2270 kg); Sf3; A1; CAL.

**OTHER COMMENTS:** used as an aerosol propellant; also used in refrigeration machinery requiring a refrigerant effective at negative pressure; other uses include a blowing agent for polymeric foams, fire extinguishers, chemical intermediate, and use as a solvent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### FORMALDEHYDE (HCHO, 30.0)

**CAS/DOT IDENTIFICATION #:** 50-00-00/UN1198, UN2209

**SYNONYMS:** formalin, formic aldehyde, methanal, methyl aldehyde, methylene oxide, oxymethylene.

**PHYSICAL PROPERTIES** : nearly colorless gas; pungent, suffocating odor; available commercially in aqueous solutions containing from 37 to 50% formaldehyde by weight; varying amounts of methyl alcohol may be present; soluble in alcohol and ether, except petroleum ether; very soluble in water; MP (-92°C, -134°F); BP (-21°C, -6°F); DN (1.083 g/mL at 20°C); SG (1.083); HV (5918 gcal/gmole); VD (1.03); VP (> 1 atm at 20°C); OT (0.5-1.0 ppm).

**CHEMICAL PROPERTIES**: very reactive; combines readily with many substances; polymerizes easily; pure formaldehyde has a tendency to polymerize; reacts with hydrogen chloride to form bis-chloromethyl ether; may also react with strong oxidizers, acids, phenols, and urea; slowly oxidizes to formic acid; corrosive to carbon steel; FP (60-83°C, 140-181°F); LFL/UFL (7.0%, 73%); AT (300°C, 572°F); HC (-136.42 kcal/gmole of gas at 25°C).

**EXPLOSION and FIRE CONCERNS**: flammable liquid when exposed to heat or flame; NFPA rating Health 3, Flammability 4, Reactivity 0; moderate explosion hazard; gas is a more dangerous fire hazard than the vapor; flammable vapors form explosive mixtures with air over a wide range; heating aqueous formaldehyde solutions above their flash points risks a potential for an explosion hazard; reacts explosively with oxides of nitrogen at 180°C.; violent reaction with perchloric acid and aniline, performic acids, nitromethane, magnesium carbonate, and hydrogen peroxide; ruptured storage tanks may evolve irritating fumes which may exist in toxic concentrations; use dry chemical, carbon dioxide, foam, or water spray for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (irritates eyes, nose and throat); contact (coughing, wheezing, lacrimation, irritates upper respiratory tract).

**FIRST AID**: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA**: inhalation-human  $\text{TCLo } 17\text{mg/m}^3/30\text{M}$ ; toxic effect: eye, pulmonary system; inhalation-man  $\text{TCLo } 300\mu\text{g/m}^3$ ; toxic effect: nose, central nervous system; unreported man  $\text{LDLo } 477\text{ mg/kg}$ ; oral-woman  $\text{LDLo } 108\text{mg/kg}$ ; skin-human  $150\mu\text{g}/3\text{D}$ ; eye-human  $4\text{ ppm}/5\text{M}$ ; eye-human  $1\text{ ppm}/6\text{M}$ ; EPA Cancer Risk Level (1 in a million excess lifetime risk):  $8 \times 10^{-5}\text{ mg/m}^3$ ; inhalation unit risk  $1.3 \times 10^{-5}\mu\text{g/m}^3$ .

**ACUTE HEALTH RISKS**: irritation of eyes, nose and throat; destructive to mucous membranes; wheezing; coughing; bronchial spasm; pulmonary irritation; labored breath; lacrimation; chest pains; headache; nausea; vomiting; gastrointestinal disturbances; skin reactions; burns of the nose.

**CHRONIC HEALTH RISKS**: pulmonary edema; respiratory edema; alteration of genetic material; carcinogen; hemorrhage; coma.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 1 ppm; OSHA PEL TWA 0.75 ppm; OSHA STEL 2 ppm; NIOSH REL TWA 0.016 ppm; IDLH 20 ppm.

**PERSONAL PROTECTION**: wear chemical-resistant gloves and other protective clothing; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP**: use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; absorb as much as possible with noncombustible materials such as dry earth, sand or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS**: absorb in dry earth or sand and place in a sanitary landfill; store in a cool, dry, well-ventilated place; isolate from oxidizing materials, alkalis, acids, and amines; special temperature control is recommended.

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**REGULATORY INFORMATION:** CA2; F2; R4; R7; U waste #; (U112); Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf1; Sf2; Sf3; CW1; CW2; A1; A2; A4; A5; CAL; DOT hazard class/division (3); labels (flammable liquid, corrosive).

**OTHER COMMENTS:** used in the production of amino, phenolic, and polyacetal resins; used in the manufacture of wood products, plastics, fertilizers and foam insulation; used as a preservative, disinfectant and antibacterial food additive.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 12; 13; 14.

**FORMIC ACID (HCOOH, 46.03)****CAS/DOT IDENTIFICATION #:** 64-18-6/UN1779**SYNONYMS:** formylic acid, hydrogen carboxylic acid, methanoic acid.

**PHYSICAL PROPERTIES :** colorless fuming liquid; usually used in 90% aqueous solution; pungent, penetrating odor; sour taste; miscible with ether, acetone, ethyl acetate, methanol, and ethanol; miscible in all proportions in water; partially soluble in benzene, toluene and xylenes; 77.5 wt% formic acid forms an azeotropic mixture with water; MP (9°C, 47°F); BP (101°C, 213°F); DN (1.220 g/mL at 20°C); LSG (1.22); ST (37.6 dynes/cm at 20°C); VS (1.804 cP at 20°C); CP (99.0 J/K-mol liquid at 25°C); HV (20.1 kJ/mol at 25°C); VD (1.59); VP (35 mmHg at 20°C); OT (1,700 mg/L water).

**CHEMICAL PROPERTIES:** combustible liquid; may deteriorate in normal storage; corrosive to metals; may react with alkalies and oxidizing materials such as peroxides, nitric acid, and chromic acid; strong reducing agent; FP (50°C, 122°F); LFL/UFL (18%, 57%); AT (601°C, 813°F); HF (-424.7 kJ/mol liquid at 25°C); H<sub>f</sub> (12.7 kJ/mol at 281.4K).

**EXPLOSION and FIRE CONCERNS:** combustible liquid when exposed to heat or flame; NFPA rating Health 3, Flammability 2, Reactivity 0; reacts vigorously with oxidizing materials; explosive reaction with furfuryl alcohol, hydrogen peroxide, thallium trinitrate trihydrate, nitromethane, and diphosphorus pentoxide; incompatible with strong oxidizers, strong caustics and concentrated sulfuric acid; decomposes slowly during storage and more rapidly under fire conditions, forming carbon monoxide; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, vomiting, damage to nasal and respiratory passages); skin absorption (hematuria, albuminuria); skin contact (dermatitis, severe eye and skin burns).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with large amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man T<sub>CLo</sub> 7300µg/m<sup>3</sup>/8H; oral-woman LD<sub>Lo</sub> 2440µg/kg.

**ACUTE HEALTH RISKS:** eye irritation; throat irritation; lacrimation; nasal discharge; coughing; dyspnea; nausea; vomiting; convulsions.

**CHRONIC HEALTH RISKS:** albuminuria; hematuria; severe eye and skin irritant; dermatitis; target organs: eyes, skin and respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (9.4 mg/m<sup>3</sup>); ACGIH TLV STEL 10 ppm (19mg/m<sup>3</sup>); OSHA PEL TWA 5 ppm (9 mg/m<sup>3</sup>); NIOSH REL TWA 5 ppm (9 mg/m<sup>3</sup>); IDLH 30 ppm.

**PERSONAL PROTECTION:** wear rubber overclothing, including chemical resistant gloves; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; flush spills with large amounts of water and dilute spills to nonflammable mixtures; neutralize spill and washings with soda ash or lime; absorb small quantities on paper towels and evaporate in a fume hood; absorb large quantities with noncombustible materials and neutralize with lime; atomize large quantities in a suitable combustion chamber equipped with an effluent gas cleaning device.

**DISPOSAL AND STORAGE METHODS:** dissolve in flammable solvent and burn in incinerator equipped with afterburner and effluent gas cleaning device; package solid acid in paper and burn in an incinerator; store in a dry, well-ventilated location; separate from oxidizing materials and alkaline substances.

**REGULATORY INFORMATION:** R4; R6; R8; U waste # (U123); Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sf1; Sf3; CW1; CW2; A1; CAL; DOT hazard class/division (8) labels (corrosive).

**OTHER COMMENTS:** used as an acidulating agent in textile dyeing and finishing; coagulates latex in rubber production; an additive in animal feed and a food preservative; meta salts made from formic acid include nickel, cadmium, and potassium formate; nickel formate may be used in the preparation of supported nickel catalysts; reported uses include non-alcoholic beverages (1.0 ppm), ice cream (5.0 ppm), candy (5.0-18 ppm), baked goods (5.0-6.1 ppm).

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14.

### FURFURAL (C<sub>4</sub>H<sub>3</sub>OCHO, 96.1)

**CAS/DOT IDENTIFICATION #:** 98-01-1/UN1199

**SYNONYMS:** fural, 2-furaldehyde, 2-furancarboxaldehyde, 2-furfural, furfuraldehyde, furfurol.

**PHYSICAL PROPERTIES :** colorless to amber liquid; almond-like odor; turns yellow to brown on exposure to air and light; very soluble in alcohol and ether; partial solubility in water; MP (-39°C, -38°F); BP (162°C, 323°F); DN (1.1563 g/mL at 25°C); LSG (1.16); ST (43.09 mN/m at 25°C); CP (163.2 J/K-mol liquid at 25°C); HV (43.22 kJ/mol at 435K); VD (3.31); VP (2 mmHg at 20°C).

**CHEMICAL PROPERTIES:** flammable and combustible liquid; may polymerize on contact with strong acids or strong alkalis; reacts with oxidizing materials; volatile in steam; FP (60°C, 140°F); LFL/UFL (2.1%, 19.3%); AT (316°C, 601°F); HF (-201.6 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 3, Flammability 2, Reactivity 0; flammable liquid when exposed to heat or flame; moderate explosion hazard; polymerizes explosively upon contact with strong mineral acids or alkalis; mixture with sodium hydrogen carbonate ignites spontaneously; keep away from heat and open flames; combustion produces irritating fumes and toxic gases; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory system); skin absorption (headache, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with water; provide respiratory support or oxygen.

**HUMAN TOXICITY DATA:** sister chromatid exchange-human lymphocyte 70 μmol/L; inhalation-human TClO 310 μg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory system; destructive to tissues of mucous membranes; central nervous system poison; headache; dangerous for acute effects resulting from exposure to furfural are minimized because of its low volatility.

**CHRONIC HEALTH RISKS:** may alter genetic material; dangerous eye irritant; dermatitis; target organs: eyes, skin and respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (skin); OSHA PEL TWA 5 ppm (20 mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear uniform, apron, and rubber gloves and other protective clothing; self-contained breathing apparatus and splash-proof safety goggles are recommended.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with sand or other noncombustible absorbent material and place into container for later disposal; flush area with water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry, well-ventilated flammable liquid storage area or cabinet; keep container tightly closed.

**REGULATORY INFORMATION:** U waste # (U125); Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sfl; CW1; CW2; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of furfuralphenol plastics; used in the manufacture of varnishes; solvent for cellulose acetate, nitrate cotton, and gums; used in the synthesis of furan derivatives and in the preparation of pyromucic acid; also used as an insecticide, fungicide and germicide; reagent in analytical chemistry.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 9; 10; 12; 14.

## FURFURYL ALCOHOL (C<sub>5</sub>H<sub>6</sub>O<sub>2</sub>, 98.11)

**CAS/DOT IDENTIFICATION #:** 98-00-0/UN2874

**SYNONYMS:** 2-furancarbinol, 2-furanmethanol, furfural alcohol, furyl alcohol, 2-furylmethanol, 2-hydroxymethylfuran.

**PHYSICAL PROPERTIES :** colorless to amber liquid; clear, mobile liquid; becomes brown to dark red upon exposure to light and air; may also turn black in presence of air; faint, burning odor; bitter taste; very soluble in alcohol and ether; soluble in all proportions in water; miscible with water in all proportions above 21°C; miscible with most organic solvents, including chloroform and benzene; immiscible with petroleum hydrocarbons and most oils; insoluble in paraffin hydrocarbons; MP (-14.6°C, 5.7°F); BP (170°C, 338°F at 760 mmHg); DN (1.1296 g/mL at 20°C); LSG (1.13); ST (0.038 N/m at 20°C); CP (204.0 J/K-mol liquid at 25°C); HV (64.43 kJ/mol at 25°C); VD (3.37); VP (0.609 mmHg at 25°C).

**CHEMICAL PROPERTIES:** combustible liquid; unstable in water (decomposes); contact with organic acids may lead to polymerization; can react with oxidizing materials; highly resistant to chemical attack; easily resinified by acids; FP (65°C, 149°F); LFL/UFL (1.8%, 16.3%); AT (490°C, 915°F); HC (-6,200 cal/g, -260 x 10<sup>5</sup> J/kg); HF (-276.2 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 1, Flammability 2, Reactivity 1; flammable when exposed to heat or flame; moderately explosive upon exposure to heat or flame; autopolymerizes explosively with acid catalysts to form a thermoset-

ting resin that cures to an insoluble, infusible solid; violent reaction with formic acid and cyanoacetic acid and heat; ignites on contact with 85% hydrogen peroxide; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, nausea, irritates nose and throat); contact (inflammation of eyes, corneal opacity, dryness of skin, irritates skin); ingestion (headache, nausea, vomiting, irritates mouth and stomach).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if swallowed, drink large amounts of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes and mucous membranes; irritation of nose and throat; headache; dizziness; nausea; diarrhea; diuresis; vomiting; body temperature depression; respiration.

**CHRONIC HEALTH RISKS:** dermatitis; target eyes, skin, respiratory system, and central nervous system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm; ACGIH TLV STEL 15 ppm (skin); OSHA PEL TWA 50 ppm (200mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (40 mg/m<sup>3</sup>); NIOSH REL STEL 15 ppm (60mg/m<sup>3</sup>)(skin); IDLH 75 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or full face shield where splashing is possible; wear full face-piece self-contained breathing apparatus if the exposure limit is exceeded; maintain eye wash fountain and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** stop or control the leak if possible; use water spray to cool and disperse vapors; control runoff and isolated discharged material for proper disposal.

**DISPOSAL AND STORAGE METHODS:** incineration is the recommended method of disposal; dissolve in a more flammable solvent and burn in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from strong oxidizing materials and strong acids; outside or detached storage is preferred.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a solvent for cellulose ethers and esters, dyes, and natural resins; used in the manufacturing of phenolic resins and dark-colored thermosetting resins; chemical intermediate for tetrahydrofurfuryl alcohol; also used in the manufacture of wetting agents, furan polymers, corrosive resistant sealants and cements; useful as a liquid propellant.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 11; 12; 14.

**GRAIN DUST (oat, wheat, barley)** (Properties such as molecular formula and formula weight depend upon the specific component of the grain dust)

**CAS/DOT IDENTIFICATION #:** none/none

**SYNONYMS:** none; (NOTE: The composition of grain dust includes 60-75% organic materials (cereal grains), 25-40% inorganic materials (solid), as well as fertilizers, pesticides and microorganisms).

**PHYSICAL PROPERTIES:** oats, barley, or wheat dust containing microbial flora and fauna; each type of dust contains husk and consists of a distinct assortment of particles; wheat and barley dusts consist of particles characterized by smooth, transparent, colorless, hollow cones that are elongated and taper to a point at the end; particles are 10 $\mu$ m in diameter and range from 100 to 200 $\mu$ m in length; wheat starch grains are circular in shape, are of light color, and occur in conglomerates; particles are 10 to 40 $\mu$ m in diameter; quartz particles are found in practically all samples of grain dust, characterized by their hexagonal structure and transparent appearance.

**CHEMICAL PROPERTIES:** properties depend upon the specific component of the grain dust; is a chemically inert dust; no reactivities and incompatibilities have been reported; no hazardous decomposition products have been reported.

**EXPLOSION and FIRE CONCERNS:** not expected to be a fire hazard; not expected to be an explosion hazard; NFPA rating (none); in case of fire in the surroundings, all extinguishing agents may be used for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and upper respiratory system); contact (cough, wheezing, increased sputum production, asthma, bronchitis, rhinitis, chronic obstructive lung disease, conjunctivitis, headache, feverish sensation, dermatitis).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; after breathing large amounts of this chemical, move exposed person to fresh air; other measures are usually not necessary.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** acute irritation of upper respiratory tract, eyes, and skin; cough; dyspnea (breathing difficulty); wheezing; asthma; bronchitis; rhinitis; conjunctivitis; grain fever (characterized by facial warmth, headache, feverish sensation, chilliness, throat and tracheal burning, chest tightness, cough, expectoration, dyspnea, malaise, and myalgia).

**CHRONIC HEALTH RISKS:** irreversible permanent damage to lungs; chronic cough, phlegm, wheezing, and dyspnea; increased prevalence of chronic bronchitis; chronic obstructive lung disease; fibrosis of the lungs in grain workers have been reported; a high level of dust exposure may induce silicosis in some workers; interstitial lung disease may occur.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup> (total particulates); OSHA PEL TWA 10 mg/m<sup>3</sup>; NIOSH REL TWA 4 mg/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, paper gloves, sleeves, apron or coveralls; use dust-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; it is recommended that a dust respirator be used; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** collect spilled material and deposit in sealable containers for reclamation or proper disposal; use vacuuming or wet method to eliminate dispersion of dust; do not dry sweep.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in a secured, sanitary landfill; three types of elevators (country, terminal, and transfer) are employed to process grain

before it reaches its final destination; farmers truck their crops to country elevators where the grain is graded, cleaned, and stored; the grain is then shipped to terminal elevators, where it is processed and stored in an annex of concrete silos; the transfer elevators then store the grain until it is shipped to local feed and flour mills, breweries and foreign markets.

**REGULATORY INFORMATION:** in 1984, the United States Occupational Safety and Health Administration proposed rigid housekeeping regulations to reduce accumulations of fugitive grain dust in all grain handling facilities in order to reduce the risk of explosions.

**OTHER COMMENTS:** silicon dioxide, soil, and a wide variety of other compounds containing many trace elements comprise the inorganic matter in grain dust; a large number of chemicals are used in the grain industry; herbicides are used to control the growth of weeds in crops; harvested grain may be protected during storage in elevators and during transport by use of aluminum phosphide; particles from rodents, insects, weevils, birds, and their excreta can be found in grain dust; in addition, a wide variety of mite species are found in grain dust, and this amount of mite material is directly related to the water content of the dust.

**KEY REFERENCES:** 4; 16.

### GLYCERIN (MIST) (C<sub>3</sub>H<sub>5</sub>(OH)<sub>3</sub>, 92.09)

**CAS/DOT IDENTIFICATION #:** 56-81-5/none

**SYNONYMS:** glycerin (anhydrous), glycerol, glyceryl alcohol, 1,2,3-propanetriol, trihydroxypropane.

**PHYSICAL PROPERTIES :** clear, colorless, syrupy liquid; odorless; sweet warm taste, about 0.6 times as sweet as cane sugar; absorbs moisture from air (hygroscopic); also absorbs hydrogen sulfide, hydrogen cyanide, and sulfur dioxide; solidifies after prolonged cooling at 0°C (32°F) forming shiny orthorhombic crystals; solid form melts above 64°F; miscible with water and alcohol; insoluble in ether, benzene, chloroform, carbon tetrachloride, carbon disulfide, and in fixed and volatile oils; MP (18°C, 64°F); BP (290°C, 554°F); DN (1.260 g/mL at 20°C); LSG (1.26); VS (923 mPa-s at 25°C); CP (218.9 J/K-mol liquid at 25°C); HV (61.04 kJ/mol at 563.2K); VD (3.17); VP (0.0025 mmHg at 50°C (122°F)).

**CHEMICAL PROPERTIES:** stable in air; stable under ordinary conditions of use and storage; hazardous polymerization will not occur; aqueous solutions are neutral to litmus; can react with strong oxidizers; FP (199°C, 390°F); LFL/UFL (unknown); AT (370°C, 698°F); HF (-668.5 kJ/mol liquid at 25°C); H<sub>f</sub> (18.28 kJ/mol at 291.3K).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; slight fire hazard when exposed to heat or flame; NFPA rating Health 1, Flammability 1, Reactivity 0; vapor-air mixtures are explosive above flash point; can react violently with acetic anhydride, calcium oxychloride, chromium oxides, and alkali metal hydrides; forms highly explosive mixtures with hydrogen peroxide; forms explosive glyceryl nitrate when mixed with nitric acid and sulfuric acid; mixture with perchloric acid and lead oxide forms explosive perchlorate esters; confined mixture with chlorine will explode if heated to 70-80°C (158-176°F); ignites on contact with potassium permanganate and calcium hypochlorite; energetic reaction with sodium hydride; due to evolution of gas, mixture with nitric acid and hydrofluoric acid is a storage hazard; decomposes upon heating above 290°C, forming acrolein (a corrosive agent); use any means suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory tract); contact (impaired kidney function, irritates eyes, and skin); ingestion (headache, nausea, vomiting, diarrhea).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if ingested, induce vomiting immediately and get medical attention.

**HUMAN TOXICITY DATA:** oral-human TDLo 1428 mg/kg; toxic effect: central nervous system, gastrointestinal tract; dna inhibition-human lymphocyte 200 mmole/L

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; nausea; headache; diarrhea; vomiting.

**CHRONIC HEALTH RISKS:** may cause kidney injury; may aggravate pre-existing skin disorders, eye problems, or impaired liver or kidney function.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg(vapor)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; wear chemical safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect liquid in a suitable container or absorb with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** manage whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated area; keep in tightly closed containers and protect against physical damage; separate from incompatible substances; avoid heat, flames, and ignition sources.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a solvent, plasticizer, humectant, emollient, sweetener, etc.; used in the manufacture of nitroglycerol (dynamite), cosmetics, pharmaceuticals, food-stuffs, special soaps, lubricants, printing and copying inks, lead oxide cements, and antifreeze mixtures; also used in fermentation nutrients in the production of antibiotics.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **GLYCIDOL (C<sub>3</sub>H<sub>6</sub>O<sub>2</sub>, 74.09)**

**CAS/DOT IDENTIFICATION #:** 556-52-5/UN2810

**SYNONYMS:** 2,3-epoxy-1-propanol, epoxypropyl alcohol, glycide, glycidyl alcohol, hydroxymethyl ethylene oxide, 2-hydroxymethyl oxiran, 3-hydroxypropylene oxide, oxirane methanol.

## 650 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**PHYSICAL PROPERTIES** : colorless liquid; slightly viscous; soluble in alcohol and ether; miscible with water; MP (-45°C, -49°F); BP (166°C, 331°F); DN (1.165 g/mL at 0°C); LSG (1.12); VD (2.15); VP (0.9 mmHg at 25°C); R Vapor/Air D: (1.0 at 20°C).

**CHEMICAL PROPERTIES**: combustible liquid; attacks plastic and rubber; reacts vigorously with strong oxidizers and nitrates; FP (72°C, 162°F); LFL/UFL (NA); AT (415°C, 779°F).

**EXPLOSION and FIRE CONCERNS**: combustible; NFPA rating (NA); explosive vapor/air mixtures may be formed above 72°C; decomposes on contact with strong acids and bases, water, metal salts (e.g., aluminum chloride, ferric chloride, tin (IV) chloride), and metals (e.g. copper, zinc), causing fire and explosion hazard; use carbon dioxide, alcohol-resistant foam, powder, or water spray for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (cough, dizziness, labored breathing, irritates eyes, skin, nose and throat); skin/eye contact (redness, pain); ingestion (abdominal pain).

**FIRST AID**: rinse eyes with plenty of water for several minutes; rinse skin with plenty of water or shower; provide oxygen or artificial respiration if indicated; if swallowed, rinse mouth and drink plenty of water; do not induce vomiting and get immediate medical attention.

**HUMAN TOXICITY DATA**: cytogenic analysis-human lymphocyte 400µmol/L.

**ACUTE HEALTH RISKS**: irritation of eyes, skin and respiratory tract; cough; dizziness; labored breathing; lung edema; effects on central nervous system; lowering of consciousness; abdominal pain; nervous excitation; depression.

**CHRONIC HEALTH RISKS**: skin sensitization; possibly carcinogenic to humans; possibly causes toxic effects upon human reproduction.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 25ppm(76mg/m<sup>3</sup>); OSHA PEL TWA 50 ppm (150 mg/m<sup>3</sup>); NIOSH REL TWA 25 ppm (75 mg/m<sup>3</sup>); IDLH 150ppm.

**PERSONAL PROTECTION**: wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield where splashing is possible; system of local exhaust ventilation is recommended in order to control the emissions of the contaminate at its sources and to prevent dispersion of it into the general work area; a closed system should be used above 72°C; wear a full-facepiece self-contained breathing apparatus if the exposure limit is exceeded.

**SPILL CLEAN-UP**: collect leaking and spilled liquid in sealable glass or mild steel containers as far as possible; absorb remaining liquid in noncombustible materials such as dry earth, sand, or other inert absorbent.

**DISPOSAL AND STORAGE METHODS**: absorb in dry sand or inert absorbent and place in a secured sanitary landfill; store in a cool, dry location with plenty of ventilation along the floor; separate from strong bases, strong acids, food and feedstuffs.

**REGULATORY INFORMATION**: T120-c13; A1; CAL.

**OTHER COMMENTS**: used as a chemical intermediate in the synthesis of glycerol, glycidyl ethers, and amines; stabilizer in the manufacture of vinyl polymers and additive for oil and synthetic hydraulic fluids; also useful as an epoxy resin diluent, a demulsifier, and a dye-leveling agent.

**KEY REFERENCES**: 3; 4; 5; 6; 7; 14.

**GRAPHITE, NATURAL (C, 12.01)****CAS/DOT IDENTIFICATION #:** 7782-42-5/none**SYNONYMS:** black lead, mineral carbon, plumbago, sliver graphite, stove black.

**PHYSICAL PROPERTIES :** steel gray to black solid with a metallic sheen; relatively soft, greasy feeling solid; odorless; soluble in molten iron; negligible solubility in water; compressive strength usually approximately 2000-8000 psi; MP (3650°C, 6602°F); BP (sublimes); DN (2.0-2.25 g/cm<sup>3</sup>, depending upon origin); SG (2.0-2.25); CP (8.5 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg approximately); TS (400-2000 psi); MOHS' HARDNESS (1.0).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; resistant to oxidation and thermal shock; high electrical and thermal conductivity; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible solid; not expected to be a fire hazard; no information found on explosion hazards; incompatible with very strong oxidizers, including fluorine, chlorine trifluoride and potassium peroxide; hazardous decomposition products include carbon monoxide and carbon dioxide; use alcohol foam, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract, difficult breathing, pulmonary function impairment, coughing); contact (eye irritation); ingestion (no symptoms identified).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, move exposed person to fresh air and provide oxygen; if not breathing, provide respiratory support; if large amounts were swallowed, drink plenty of water and seek medical advice.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of upper respiratory tract; cough; dyspnea ;back sputum; decreased pulmonary function.

**CHRONIC HEALTH RISKS:** lung fibrosis; aggravation of pre-existing conditions, including sinus problems, pulmonary disease, and skin disorders.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2mg(respirable dust)/m<sup>3</sup>; OSHA PEL TWA 15 mppcf (respirable dust); NIOSH REL TWA 2.5 mg(respirable dust)/m<sup>3</sup>; IDLH 1250 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear clean-body covering clothing and protective gloves; use chemical safety goggles and/or a full-face shield where dusting or splashing of solutions is possible; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; wear self-contained breathing apparatus operated in a positive pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** with clean-shovel, carefully place material into clean, dry container and cover; take up remaining material with an inert, damp noncombustible material; flush spill area with water; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** manage whatever cannot be saved for recovery or recycling in an appropriate and approved waste disposal facility; dispose of container

and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; keep away from heat, sparks, and flame; separate from strong oxidizing materials.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used for lead pencils, crucibles, stove polish, molds, lubricants, paints, and coatings; other uses include electroplating, cathodes in electrolytic cells, matches, and explosives.

**KEY REFERENCES:** 3; 4; 5; 7; 8; 14.

### **GRAPHITE, SYNTHETIC (C, 12.0)**

**CAS/DOT IDENTIFICATION #:** not available/UN 1362 (carbon, activated)

**SYNONYMS:** activated carbon, synthetic graphite.

**PHYSICAL PROPERTIES :** gray-black solid; odorless; insoluble in water; commercial varieties usually withstand temperatures up to 2820°C (5108°F); MP (3650°C, 6602°F); BP (sublimes); DN (1.5-1.8 g/cm<sup>3</sup>, depending upon origin); SG (1.72); CP (8.5 J/K-mol crystal at 25°C); VD (NA); VP ( 0 mmHg approximately); TS (400-2000 psi); MOHS' HARDNESS (1.0).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; avoid contact with high temperatures (above 400°C); will oxidize slowly in air at temperatures of 400°C or greater; electrically conductive; FP (NA); LFL/UFL (NA); AT NA).

**EXPLOSION and FIRE CONCERNS:** considered only slight fire hazard when exposed to heat; very slight explosion hazard in form of fine dust when exposed to heat or flame; material may burn, but will not ignite readily; combustion produces carbon dioxide and possibly carbon monoxide; incompatible with strong oxidizing agents, including fluorine, chlorine trifluoride and potassium hydroxide; use dry chemical, foam, water or sand for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract, difficult breathing, pulmonary function impairment, coughing); contact (eye irritation); ingestion (no symptoms identified).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, move exposed person to fresh air and provide oxygen; if not breathing, provide respiratory support; if large amounts were swallowed, drink plenty of water and seek medical advice.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of upper respiratory tract; cough; dyspnea ;back sputum; decreased pulmonary function.

**CHRONIC HEALTH RISKS:** lung fibrosis; aggravation of pre-existing conditions, including sinus problems, pulmonary disease, and skin disorders.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 15 mg (total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH IDLH (not determined).

**PERSONAL PROTECTION:** wear clean-body covering clothing and protective gloves; use chemical safety goggles and/or a full-face shield where dusting or splashing of solutions is possible; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; wear self-contained breathing apparatus operated in a positive pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** with clean-shovel, carefully place material into clean, dry container and cover; take up remaining material with an inert, damp noncombustible material; flush spill area with water; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** manage whatever cannot be saved for recovery or recycling in an appropriate and approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; keep away from heat, sparks, and flame; separate from strong oxidizing materials.

**REGULATORY INFORMATION:** A1.

**OTHER COMMENTS:** produced synthetically by heating petroleum coke to approximately 3000°C (5432°F) in an electric resistance furnace; in the United States, 70% of graphite is synthetic; used for lead pencils, crucibles, stove polish, molds, lubricants, paints, and coatings; other uses include electroplating, cathodes in electrolytic cells, matches, and explosives.

**KEY REFERENCES:** 3; 4; 5; 7; 8; 14.

## **GYPSSUM (CaSO<sub>4</sub>·2H<sub>2</sub>O, 172.18)**

**CAS/DOT IDENTIFICATION #:** 13397-24-5/none

**SYNONYMS:** calcium (II) sulfate dihydrate, gypsum stone, hydrated calcium sulfate, mineral white.

**PHYSICAL PROPERTIES :** white crystalline powder or colorless, hygroscopic crystals, odorless, tasteless powder; loses only part of its water at 100-150°C (212-302°F); becomes anhydrous at 163°C (325°F); soluble or slightly soluble in water; very slowly soluble in glycerol; practically insoluble in most organic solvents; MP (128°C, 262°F (loses 1 1/2 H<sub>2</sub>O)); 163°C, 325°F (loses 2 H<sub>2</sub>O)); BP (163°C, 325°F); DN (2.32 g/mL at 25°C and 760 mmHg); SG (2.3); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; incompatible with aluminum at high temperatures; reacts vigorously with diazomethane; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); IR (1.525).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); violent reaction can occur upon heating when mixed with aluminum powder; explosive mixture with diazomethane vapor can result from an exothermic reaction; will ignite at high temperatures when mixed with phosphorus; heating to decomposition emits toxic fumes of oxides of sulfur; in case of fire in the surroundings, all extinguishing agents allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, sore throat, labored breathing, irritates eyes, skin and mucous membranes); contact (conjunctivitis, sneezing, coughing, nosebleed, discharge of thin nasal mucus); ingestion (intestinal obstruction may occur if material hardens).

## 654 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; upon inhalation, move exposed person to fresh air; if swallowed, drinking glycerin, gelatin solutions, or large volumes of water may delay hardening.

**HUMAN TOXICITY DATA:** inhalation-human  $TCLo$   $194/g/m^3/10Y$  intermittent; toxic effect: nose, pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and mucous membranes; irritation to upper respiratory system; conjunctivitis; rhinitis; epistaxis (nosebleed); coughing; sneezing; sore throat; labored breathing; pneumonia.

**CHRONIC HEALTH RISKS:** long-term or repeated exposure may have effects on the eyes and respiratory tract; may result in conjunctivitis, rhinitis, laryngitis and pharyngitis; may cause impaired sense of smell and taste; fibrosing alveolitis (growth of fibrous tissue in the lung) may develop.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $10\text{ mg (total dust)}/m^3$ ; OSHA PEL TWA  $15\text{ mg (total dust)}/m^3$ ,  $5\text{ mg (respirable fraction)}/m^3$ ; NIOSH REL TWA  $10\text{ mg (total dust)}/m^3$ ,  $5\text{ mg (respirable fraction)}/m^3$ ; IDLH (not determined).

**PERSONAL PROTECTION:** loose-fitting clothing made of dust-tight material should be worn when working with calcium sulfate; wear chemical safety goggles, as well as a dust mask; a closed system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use positive pressure self-contained breathing apparatus in unknown concentrations; for extra personal protection, use a P1 filter respirator for inert particles; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; sweep spilled substance into sealable containers; moisten spill to prevent dusting; vacuum spill or use other methods which avoid raising dust; wash away remaining material with plenty of water.

**DISPOSAL AND STORAGE METHODS:** landfilling is the suggested disposal method for this substance; dispose of in accordance with federal, state, and local regulations; store in a cool area with adequate ventilation; the dihydrate should be kept dry; separate from aluminum powder, diazomethane vapor, and phosphorus.

**REGULATORY INFORMATION:** A1; hazardous substances and reportable quantities (not listed); RCRA hazards waste number (not listed); TSCA inventory (listed); special provisions for shipping regulations (not listed).

**OTHER COMMENTS:** the dihydrate form of calcium sulfate is generally referred to as gypsum; the dihydrate form of calcium sulfate is used in water and soil treatment, paints, enamels, polishing powders, paper, insecticide dusts, pharmaceuticals, and animal feed; has also been utilized in the manufacture of Portland cement, plaster of Paris yeast, artificial marble, calcium carbide, ammonium sulfate, sulfuric acid, and polymers; the food and pharmaceutical grade is also used as a source of calcium in foods.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 15.

**HAFNIUM (Hf, 178.49)**

**CAS/DOT IDENTIFICATION #:** 7440-58-6/UN2545 (powder, dry); UN1326 (powder, wet).

**SYNONYMS:** celtium, elemental hafnium, hafnium metal.

**PHYSICAL PROPERTIES :** highly lustrous, ductile, grayish solid; hexagonal crystal structure; resembles zirconium and thorium; insoluble in water; high strength; MP (2227°C, 4041°F); BP (4602°C, 8316°F); DN (13.31 g/cm<sup>3</sup> at 20°C); SG (13.31); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** high thermal neutron cross section; resists atmospheric corrosion because of oxide film; not attacked by cold mineral acids except hydrogen fluoride; not attacked by alkalis; evaporation at 20°C is negligible; reacts vigorously with strong oxidizers and chlorine; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** spontaneously combustible flammable solid; NFPA rating (NA); dust explosion possible if in powder form (either dry or with <25% water); finely divided powder can be ignited by static electricity; may explosively decompose with friction, shock, concussion, heat, sparks, or exposure to air; powder may self-explode; powder may spontaneously ignite when heated with nitrogen, phosphorus, oxygen, sulfur, nonmetals, or halogens; reacts violently with hot nitric acid and strong oxidants; use special powder for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and mucous membranes); ingestion (liver damage, injury to the lungs).

**FIRST AID:** wash eyes immediately with large amounts of water; rinse and then wash skin with water and soap; provide oxygen or artificial respiration.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; destructive to tissues of mucous membranes; difficult breathing.

**CHRONIC HEALTH RISKS:** lungs may be affected by repeated or prolonged exposure; may have effects on the liver.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5mg/m<sup>3</sup>; OSHA PEL TWA 0.5 mg/m<sup>3</sup>; NIOSH REL TWA 0.5 mg/m<sup>3</sup>; IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use dust-proof safety goggles; wear self-contained breathing apparatus with full face-piece operated in positive pressure mode; prevent deposition of dust; dust explosion-proof electrical equipment and lighting are recommended; extra personal protection: P2 filter respirator for harmful particles.

**SPILL CLEAN-UP:** evacuate danger area; wet powder to prevent dusting and ignition, then carefully collect powder into sealable containers; do not absorb in saw-dust or other combustible absorbents and do not wash away into sewer; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** wet powder, then carefully collect powder into sealable containers and remove to a safe place; fireproof storage area; keep under water; separate from strong oxidants, strong bases, halogens, phosphorus, and sulfur.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (4.2)(UN2545); labels (spontaneously combustible); DOT hazard class/division (4.1)(UN1326); labels (flammable solid).

**OTHER COMMENTS:** used in control rods in water-cooled nuclear reactors; used in light-bulb filaments, electrodes, special glasses, and vacuum tube getter; note: powder is normally handled wetted with no less than 25% of water to reduce the fire and explosion risk.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### HEPTACHLOR (C<sub>10</sub>H<sub>5</sub>Cl<sub>7</sub>, 373.35)

**CAS/DOT IDENTIFICATION #:** 76-44-8/UN2761

**SYNONYMS:** 3-chlorochlordene, drinox, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene, heptagan, heptamul.

**PHYSICAL PROPERTIES :** white to light tan crystals; camphor-like odor; soluble in most organic solvents, including acetone, benzene, carbon tetrachloride, cyclohexanone, alcohol, and xylene; insoluble in water; MP (95-96°C, 203-205°F); BP (135-145°C, 275-293°F at 1.5 mmHg); DN (1.65-1.67 g/cm<sup>3</sup>); SG (1.66); VD (NA); VP (3 x 10<sup>-4</sup> mmHg at 25°C); OT (0.02 ppm in water).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; stable under normal temperatures and pressures; stable to light, moisture, and air; reacts with strong oxidants; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** not combustible; liquid formulations containing organic solvents may be flammable; NFPA rating (not rated); explosion hazard will be dependent on the solvent used or on the characteristics of the dust; containers may explode on heating; reacts vigorously with oxidizing materials; incompatible with iron and rust; decomposes on heating producing toxic fumes of chlorine and hydrogen chloride; use dry chemical, alcohol-resistant foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, tremors, convulsions, blood disorders); skin absorption (feeling of anxiety, irritability, muscle twitching, loss of memory, inability to concentrate); ingestion (liver and kidney damage).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if ingested, get immediate medical attention.

**HUMAN TOXICITY DATA:** microsomal mutagenicity assay-human fibroblast 100µmol/L; EPA Cancer Risk Level (1 in a million excess lifetime risk) 8 x 10<sup>-7</sup> mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** tremors; convulsions; kidney damage; respiratory collapse; liver impairment; vomiting; death.

**CHRONIC HEALTH RISKS:** dizziness; muscle tremors; loss of memory; loss of concentration; changes in personality; liver damage; damage to the kidneys; blood dyscrasias; may possibly cause damage to reproductive system; possible carcinogenic to humans; heptachlor epoxide has been found in human milk in areas with high heptachlor exposure in the population.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>(skin); ACGIH TLV STEL 2 mg/m<sup>3</sup>; OSHA PEL TWA 0.5 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup>(skin); IDLH 35mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear dust-proof safety goggles in combination with breathing protection; a system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; use self-contained breathing apparatus in oxygen deficient atmospheres.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; carefully collect remainder, then remove to a safe place; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling can be managed in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry, well ventilated area; storage should be in tightly closed containers; protect from any physical damage; keep away from excessive heat, sparks, and open flames; separate from strong oxidizers, strong bases, food and feedstuffs.

**REGULATORY INFORMATION:** CA2; S2; S24; S32; S50; S61; S62; F4; R3; R4; R5; R7; R8; D waste # (D031); P waste # (P059); Reportable Quantity (RQ): 1 lb (0.454 kg); Sf1; Sf3; CW1; CW2; CW4; CW5; A1; CAL.

**OTHER COMMENTS:** EPA has discontinued use of pesticides containing heptachlor; it continues to be used for termite control by subsurface ground insertion external to the dwelling; has also been used as an insecticide for control of cotton boll weevil.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14; 15.

## HEPTANE (C<sub>7</sub>H<sub>16</sub>, 100.23)

**CAS/DOT IDENTIFICATION #:** 142-82-5/UN1206

**SYNONYMS:** dipropylmethane, n-heptane, normal-heptane.

**PHYSICAL PROPERTIES :** colorless liquid; gasoline-like odor; slightly soluble in alcohol; miscible in ether and chloroform; insoluble in water; maximum sulfur content 0.01 wt%; vapor is heavier than air; MP (-91°C, -132°F); BP (98°C, 208°F); DN (0.68368 g/mL at 20°C); LSG (0.68); ST (19.65 mN/m at 25°C); VS (0.387 mPa-s at 25°C); CP (224.7 J/K-mol liquid at 25°C); HV (36.57 kJ/mol at 25°C); VD (3.46); VP (40 mmHg at 72°F); DR (93.3-98.9°C, 200-210°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; attacks many plastics; can react vigorously with oxidizing materials; FP (-4°C, 25°F); LFL/UFL (1.1%, 6.7%); AT (285°C, 545°F); HC (-4.4647 x 10<sup>9</sup> J/kmol); HF (-224.2 kJ/mol liquid at 25°C); H<sub>f</sub> (14.2 kJ/mol at 182.5K).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 0; flashback along vapor trail may occur; electrostatic charges can be generated as a result of flow, agitation, etc.; vapor/air mixtures are explosive; reacts violently with strong oxidants; violent reaction with phosphorus and chlorine; heating to decomposition emits carbon dioxide and carbon monoxide; use powder, foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dullness, headache, hallucinations, vertigo, light-headedness, irritates eyes, skin and respiratory tract); skin contact (dry skin, defatting of skin); eye contact (redness, pain); ingestion (abdominal cramps, nausea, vomiting, burning sensations, no appetite, may cause aspiration into the lungs with risk of chemical pneumonia).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; give artificial respiration if indicated; if swallowed, rinse mouth and get immediate medical attention.

**HUMAN TOXICITY DATA:** inhalation-human TClo 1000 ppm/6M; toxic effect: central nervous system.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; lightheadedness; headache; giddiness; stupor; vertigo; dullness; incoordination; abdominal cramps; nausea; vomiting; loss of appetite; chemical pneumonitis; unconsciousness.

**CHRONIC HEALTH RISKS:** defatting of skin; dermatitis; may have effects on the liver, resulting in impaired functions.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 400 ppm (1640 mg/m<sup>3</sup>); ACGIH TLV STEL 500 ppm; OSHA PEL TWA 500 ppm (2000 mg/m<sup>3</sup>); NIOSH REL TWA 85 ppm (350 mg/m<sup>3</sup>); NIOSH REL CL 440 ppm/15M (1800 mg/m<sup>3</sup>/15M); IDLH 750 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles or eye protection in combination with breathing protection; a system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; use explosion-proof electrical equipment and lighting; prevent build-up of electrostatic charges (e.g., by grounding); compressed air should not be used for filling, discharging, or handling; positive pressure self-contained breathing apparatus should be employed in oxygen deficient atmospheres; a filter respirator for organic gases and vapors may be employed for extra protection; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking liquid in sealable containers; absorb remaining liquid with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush remaining spills away from exposures and dilute spills to form non-flammable mixtures; do not flush into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or other inert material, and place in a sanitary landfill; dispose of container and unused contents in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; containers should be bonded and grounded for transfers to avoid static sparks; storage areas should include explosion proof ventilation; keep away from any area where the fire hazard may be acute; separate from strong oxidants.

**REGULATORY INFORMATION:** T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used as a standard in testing knock of gasoline engines (i.e., for determining octane rating); pure normal-heptane has an octane number of zero; other uses include anesthetics, organic synthesis, preparation of laboratory reagents, and use as a solvent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**HEXACHLOROETHANE (Cl<sub>3</sub>CCCl<sub>3</sub>, 236.72)**

CAS/DOT IDENTIFICATION #: 67-72-1/UN9037

**SYNONYMS:** carbon hexachloride, ethane hexachloride, ethylene hexachloride, 1,1,1,2,2,2-hexachloroethane, hexachloroethane, perchloroethane.

**PHYSICAL PROPERTIES :** colorless crystals; camphorous odor; crystals may be rhombic, triclinic, or cubic; soluble in alcohol, benzene, chloroform, ether, hot fluoric acid, and oils; insoluble in water; readily sublimates without melting; MP (186.7°C, 368°F); BP (186.8°C, 368.2°F (triple point)); DN (2.091 g/cm<sup>3</sup> at 20°C); SG (2.09); CP (198.2 J/K-mol crystal at 25°C); HS (12.2 kcal/mol); VD (8.2); REL DN of vapor/air mixture (1.0 at 20°C); VP (1 mmHg at 32.7°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; attacks iron in the presence of moisture; reacts with alkalis and metals; FP (NA); LFL/UFL (NA); AT (NA); HF (-202.8 kJ/mol crystal at 25°C); T<sub>c</sub> (442°C, 827.6°F); P<sub>c</sub> (64.79 atm, 4.92 x 10<sup>4</sup> mmHg).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (NA); slightly explosive by spontaneous chemical reaction; reacts violently with zinc, aluminum powder, and sodium; will produce spontaneous explosive chloroacetylene by dehalogenation reaction with alkalis, metals, etc.; decomposes on heating above 300°C (572°F) producing toxic and corrosive fumes of hydrogen chloride and phosgene; use carbon dioxide, dry chemical powder, or appropriate foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, sore throat, coughing, irritates eyes, skin and upper respiratory tract); skin absorption (tremors, ataxia, sleepiness, stupor, narcosis); contact (lacrimation, redness, pain, dermatitis); ingestion (abdominal pain, nausea, vomiting, diarrhea, damage to liver and kidneys).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush affected areas of skin with plenty of soap and water; upon inhalation, remove to fresh air and provide oxygen; if not breathing, provide respiratory support; if ingested, rinse mouth with water and give a slurry of activated charcoal in water to drink; refer to medical attention immediately.

**HUMAN TOXICITY DATA:** RfD (reference dose) 0.001 mg/kg/day; inhalation unit risk estimate 4.0 x 10<sup>-6</sup> (µg/m<sup>3</sup>)<sup>-1</sup>; Group C, possible human carcinogen of low carcinogenic hazard.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; irritation of mucous membranes and upper respiratory tract; headache; dizziness; cough; sore throat; sleepiness; stupor; abdominal pain; vomiting; diarrhea; narcosis; depression of central nervous system; could cause unconsciousness.

**CHRONIC HEALTH RISKS:** may have effects on the liver and kidneys; effects on the central nervous system, including tremors and ataxia; may possibly cause cancer; prolonged exposure may cause dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm (9.7 mg/m<sup>3</sup>); OSHA PEL TWA 1 ppm (10 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 1 ppm (10mg/m<sup>3</sup>)(chloroethane) reduce to lowest level; IDLH 300 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including rubber boots, heavy rubber gloves, lab coat, apron or disposal coveralls; use dust-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spill substance into sealable containers; if appropriate, moisten first to avoid raising dust; carefully collect remainder, then remove to a safe place; wash spill site after material pickup is complete.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an appropriate waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; separate from metals, such as zinc, cadmium, aluminum, mercury, and hot iron; keep away from food and feedstuffs.

**REGULATORY INFORMATION:** CA2; S3; R3; R4; R5; R7; R8; D waste # (D034); U waste # (U131); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf3; CW4; CW5; A1; CAL.

**OTHER COMMENTS:** used in metallurgy for recovering metal from ores or smelting products, removing impurities from molten metals, and for refining aluminum alloys; used as a degassing agent for magnesium; inhibits combustion of ammonium perchlorate and explosiveness of methane; useful as a substitute for camphor in nitrocellulose; other uses include: pyrotechnics and smoke devices, polymer additive, flame-proofing agent, ignition suppressant, additive for lube oils; intermediate for pharmaceuticals and moth repellants, retarding agent in pharmaceuticals, and the producing of synthetic diamonds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14; 19.

### HEXACHLORONAPHTHALENE (C<sub>10</sub>H<sub>2</sub>Cl<sub>6</sub>, 334.82)

**CAS/DOT IDENTIFICATION #:** 1335-87-1/none

**SYNONYMS:** halowax<sup>®</sup>1014

**PHYSICAL PROPERTIES:** light yellow or white wax-like solid; pleasant, aromatic odor; insoluble in water; soluble in organic solvents; MP (137°C, 279°F); BP (344-388°C, 651-730°F); DN/SG (1.78); VD (11.6); VP (3 x 10<sup>-8</sup> mmHg at 25°C (est)).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; reacts with strong oxidizing agents; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HLC (0.000087 atm-m<sup>3</sup>/mole (est)).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; burns only at very high temperatures; NFPA rating (not rated); violent reactions occur on contact with strong oxidizers such as permanganates, nitrates, peroxides, chlorates and perchlorates; toxic gases and vapors (such as hydrogen chloride, phosgene, and carbon monoxide) may be released in a fire; use dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, irritates eyes, nose, and throat); skin absorption (confusion, jaundice, coma); skin contact (acne-like rash called chloracne, skin sensitization).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure. [note: oral-domestic animals (e.g., goat, sheep) TDLo 25,600 µg/kg/10D intermittent; toxic effects: sense organs and special senses (nose, eye, ear, and taste)-lacrimation; behavioral-somnolence (general depressed activity); skin and appendages-dermatitis, other.]

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and throat; nausea; confusion; may injure the liver, resulting in such effects as fatigue, dark urine, yellow jaundice, and possible death; can irritate the skin, causing a rash.

**CHRONIC HEALTH RISKS:** long-term exposure may cause chronic liver damage; can cause an acne-form dermatitis called chloracne; can cause the skin to become sensitive to sun exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.2 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.2 mg/m<sup>3</sup> (skin); IDLH 2 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab-coat, apron or coveralls; use splash-proof safety goggles and face shield when working with molten halowax 1014; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposures are above 0.2 mg/m<sup>3</sup>; wear self-contained breathing apparatus in unknown concentrations or under IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; collect spilled material and deposit in sealed containers for disposal in a secured, sanitary landfill; absorb liquids in vermiculite, dry sand, or earth and deposit in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in a secured, sanitary landfill; after mixing with another combustible fuel, burn large amounts in an incinerator equipped with an acid scrubber; store in a cool area; use only with adequate ventilation; store in tightly closed containers; separate from strong oxidizers, such as permanganates, nitrates, peroxides, chlorates, and perchlorates; avoid contact with any source of heat.

**REGULATORY INFORMATION:** S3; T30; T120-a; A1; CAL; DOT hazard class/division (data not found in literature); label (data not found in literature).

**OTHER COMMENTS:** used as an inert component of resins for coating or impregnating textiles and for flame and waterproofing wood paper; utilized in electric wire insulation and also as additives to special lubricants.

**KEY REFERENCES:** 4; 5; 6; 7; 14; 15.

**n-HEXANE (C<sub>16</sub>H<sub>14</sub>, 86.20)**

**CAS/DOT IDENTIFICATION #:** 110-54-3/UN1208

**SYNONYMS:** hexane, hexyl hydride, normal-hexane

## 662 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**PHYSICAL PROPERTIES:** colorless, clear liquid; gasoline-like odor; miscible with chloroform, ether, and alcohol; insoluble in water (MP -100°C to 95°C, -148°F to -139°F); BP(69°C, 156°F); DN(0.655 g/mL at 25°C); LSG(0.66); ST(17.89 mN/m at 25°C); VS(0.300 mPa-s at 25°C); CP(195.6 J/mol-K at 25°C); HV (31.56 kJ/mol at 25°C); VD(2.97); VP(124 mmHg at 20°C); OT (130 ppm).

**CHEMICAL PROPERTIES:** very volatile liquid; can react vigorously with strong oxidizers; FP (-23°C, -9.4°F); LFL/UFL (1.2%, 7.5%); AT (225°C, 437°F); HC (4,163 kJ/mol, 995 kcal/mol); HF (-198.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 0; very dangerous fire and explosion hazard when exposed to heat or flame; explodes on contact with dinitrogen tetroxide at 28°C; incompatible with oxidizing materials; may generate electrostatic charges; decomposition emits toxic vapors; use carbon dioxide or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (vertigo, drowsiness, fatigue, loss of appetite, anorexia); ingestion (nausea, vomiting, diarrhea, abdominal pain, labored breath).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 190 ppm/8W; toxic effect: peripheral nervous system.

**ACUTE HEALTH RISKS:** irritation of eyes and nose; nausea; irritation to mucous membranes; light-headedness; headache; numbness of extremities; muscle weakness; chemical pneumonia; giddiness; mild central nervous system depression; dermatitis..

**CHRONIC HEALTH RISKS:** blurred vision; headache; fatigue; polyneuropathy; muscular weakness; numbness in extremities; EPA Group D: not classified as to human carcinogenicity.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (180 mg/m<sup>3</sup>); OSHA PEL TWA 500 ppm (1800 mg/m<sup>3</sup>); NIOSH REL TWA (alkanes) 350 mg/m<sup>3</sup>; IDLH 1100 ppm.

**PERSONAL PROTECTION:** wear a gas-tight, fireproof suit; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** collect leaking and spilled liquid in sealable containers or absorb with inert materials (e.g., dry earth, sand, or vermiculite); wash remaining material with large amounts of water but not into spaces such as sewers because of danger of explosion.

**DISPOSAL AND STORAGE METHODS:** absorb spilled liquid in sand or inert absorbent, and place in secured sanitary landfill; store in a cool, dry location; use only with adequate ventilation; keep in well closed containers; fireproof if in building; separate from strong oxidants.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 5000 lbs (2270 kg); Sf3; T799B; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in determining the refractive index of minerals; used as a solvent for glues, varnishes, cements, and inks; used in the dry cleaning industry; used as an intermediate for pharmaceuticals.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 8; 12; 13; 14.

**2-HEXANONE (CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>COCH<sub>3</sub>, 100.18)****CAS/DOT IDENTIFICATION #:** 591-78-6/UN1224

**SYNONYMS:** butyl methyl ketone, n-butyl methyl ketone, mbk, methyl butyl ketone, methyl n-butyl ketone, propylacetone.

**PHYSICAL PROPERTIES :** clear, colorless liquid; acetone-like odor (i.e., odor of nail polish remover); moderate solubility in water; soluble in alcohol and ether; MP (-57°C, -71°F); BP (126-128°C, 259-262°F); DN (0.830 g/mL at 0°C); LSG (0.81); ST (25.45 mN/m at 25°C); VS (0.583 mPa-s at 25°C); CP (213.3 J/K-mol liquid at 25°C); HV (43.14 kJ/mol at 25°C); VD (3.45); REL DN vapor/air mixture (1.01 at 20°C); VP (11 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react with strong oxidizing agents; attacks plastics; FP (19°C, 66°F); LFL/UFL (1.3%, 8.1%); AT (424°C, 795°F); HV (-3.4900 x 10<sup>9</sup> J/kmol); HF (-322.0 kJ/mol liquid at 25°C); H<sub>f</sub> (14.9 kJ/mol at 217.6K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; very dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 0; above 35°C, may form explosive vapor/air mixtures; flashback along vapor trail may occur; sensitive to static discharge; closed containers may explode when exposed to heat; contact with strong oxidizers may cause fire; violent reaction with oxidants may form unstable peroxides; hazardous decomposition products include carbon monoxide and carbon dioxide; use alcohol foam, dry chemical or carbon dioxide for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (unspecified eye effects, headache, nausea, vomiting, cough, drowsiness, narcotic effects, unconsciousness, irritates eyes, skin and respiratory tract); skin contact (severe irritation, dermatitis, possible systemic effects if absorbed through skin); eye contact (severe irritation, blurred vision); ingestion (headache, abdominal pain, nausea, vomiting, diarrhea, sore throat, central nervous system effects).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; in case of ingestion, rinse mouth and induce vomiting immediately as directed by a physician.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 1000 ppm; toxic effect: eye, central nervous system, gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and nose; severe irritation of respiratory system; irritation of mucous membranes; cough; headache; dizziness; drowsiness; sore throat; may cause narcosis; central nervous system depression; gastrointestinal irritation; nausea; vomiting; diarrhea; weakness; peripheral neuropathy; may result in unconsciousness.

**CHRONIC HEALTH RISKS:** prolonged contact may cause dermatitis; may have effects on the nervous system; target organs: central nervous system, skin, respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (20 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 100 ppm (410 mg/m<sup>3</sup>); NIOSH REL TWA 1 ppm (4 mg/m<sup>3</sup>); IDLH 1600 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; above 35°C, use a system of local exhaust ventilation, as well as explosion-proof electrical

equipment; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; stop leak if possible; use water spray to cool and reduce vapors; collect leaking and spilled liquid in sealable containers; absorb remaining liquid in sand or other noncombustible material, and place in to chemical waste container for later disposals; flush spill area with water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** soak up with sand or dry earth, and place in a secured, sanitary landfill; dispose of container and unused contents in accordance with federal, state, and local regulations; store in a cool, dry location; use with adequate ventilation; storage should be in standard flammable liquids storage room or cabinet; keep containers tightly closed; containers should be bonded and grounded when transferring liquid; separate from incompatibles, such as strong oxidizers; avoid open flames and sparks.

**REGULATORY INFORMATION:** R2; R3; R5; A1 CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent; useful as a laboratory reagent; methyl butyl ketone enhances the toxicity of some other chemical substances like carbon tetrachloride, chloroform, and ethanol.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### HEXONE (CH<sub>3</sub>COCH<sub>2</sub>CH(CH<sub>3</sub>)<sub>2</sub>, 1002.)

**CAS/DOT IDENTIFICATION #:** 108-10-1/UN1245

**SYNONYMS:** isobutyl methyl ketone, methyl isobutyl ketone, 4-methyl-2-pentanone, MIBK

**PHYSICAL PROPERTIES :** colorless, mobile liquid; fruity, pleasant odor; miscible with alcohol, benzene, and ether; moderately soluble in water; MP (-85°C, -120°F); BP (117°C, 242°F); DN (0.801 g/mL at 20°C); LSG (0.8); VS (0.545 mPa-s at 25°C); HV (40.61 kJ/mol at 25°C); VD (3.5); VP (16 mmHg at 20°C); OT (0.10 ppm).

**CHEMICAL PROPERTIES:** hazardous polymerization will not occur; reacts with strong oxidizers and potassium tert-butoxide; can react vigorously with reducing agents; FP (18°C, 64°F); LFL/UFL (1.2%, 8.0% at 200°F); AT (448°C, 840°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health2, Flammability 3, Reactivity 1; may form explosive peroxides in air; moderately explosive in vapor form when exposed to heat or flame; ignites on contact with potassium tert-butoxide; incompatible with oxidizing agents, reducing agents, strong bases, air, and potassium tert-butoxide; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (defatting, dermatitis); contact (redness of eyes, tearing, blurred vision).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA:** eye-human 200ppm/15M.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and mucous membranes; headache; nausea; vomiting; dizziness; incoordination; lacrimation; blurred vision; redness of eyes; narcosis; coma; death.

**CHRONIC HEALTH RISKS:** intestinal pain; slight enlargement of liver; insomnia; weakness; nausea; headache; burning in eyes; EPA Group D: not classifiable as to human carcinogenicity.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; ACGIH TLV STEL 75 ppm; OSHA PEL TWA 100 ppm ( $410\text{mg}/\text{m}^3$ ); NIOSH REL TWA 50 ppm ( $205\text{mg}/\text{m}^3$ ); NIOSH REL STEL 75 ppm ( $300\text{mg}/\text{m}^3$ ); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand, or vermiculite and place in a sanitary landfill; atomize in a suitable combustion chamber equipped with afterburner and scrubber; store in a cool, dry place, away from oxidizers and reducing agents; outside storage is preferred.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 5000 lbs. (2270 kg); A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for gums, resins, nitrocellulose, paints, varnishes, and lacquers; used in the extraction of rare metals.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 10; 12; 13; 14.

## **SEC-HEXYL ACETATE ( $\text{C}_8\text{H}_{16}\text{O}_2$ , 144.24)**

**CAS/DOT IDENTIFICATION #:** 108-84-9/UN1233

**SYNONYMS:** 1,3-dimethylbutyl acetate, 4-methyl-2-pentanol acetate, 4-methyl-2-pentyl acetate, methylamyl acetate, methylisoamyl acetate, methylisobutylcarbinol acetate.

**PHYSICAL PROPERTIES:** clear, colorless liquid; pleasant, fruity odor; floats on water; exists in form of several isomers with boiling points ranging from 146 - 156°C (295-313°F); very soluble in ethyl ether and ethanol; insoluble in water; miscible with alcohol; MP (-63.8°C, -82.8°F); BP (147.5°C, 297.5°F); DN ( $0.8805\text{g}/\text{cm}^3$  liquid at 25°C); BULK DN (7.1/gal); LSG ( $0.86$  at 20°C); ST (25 dynes/cm at 25°C); VS ( $0.93\text{cP}$  at 20°C); HV (225 Btu/lb, 125 cal/g,  $5.23 \times 10^5\text{J}/\text{kg}$ ); VD (5.0); VP (4 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; will not react with water; can react with oxidizing materials; FP (45°C, 113°F); LFL/UFL (0.9%, 5.7% (calculated)); AT (265.6°C, 510°F); HC (-14,400 Btu/lb, -8,000 cal/g,  $-335 \times 10^5\text{J}/\text{kg}$ );  $T_c$  (319°C, 606°F, 592K);  $P_c$  (382 psia, 26 atm, 2.6 MPa).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; moderate fire risk; NFPA rating Health 1, Flammability 2, Reactivity 0; vapors may form explosive mixtures with air; flashback along vapor trail may occur; vapor may explode if ignited in an enclosed area; containers may explode when heated; incompatible with strong oxidizers, nitrates, alkalies, and ac-

ids; heating to decomposition emits carbon monoxide and carbon dioxide; use alcohol foam, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, nausea, irritates eyes, nose and throat); contact (liquid defats skin, may cause smarting and reddening of skin).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of water; if breathing is irregular or has stopped, start resuscitation and administer oxygen; in case of ingestion, seek immediate medical attention.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 100 ppm; toxic effects: sense organs and special senses (nose, eye, ear, and taste) - other changes; sense organs and special senses (nose, eye, ear and taste) - conjunctive irritation; lung, thorax, or respiration - other changes; eye-human 100 ppm/15M.

**ACUTE HEALTH RISKS:** headache, dizziness; nausea; irritation to respiratory passages; irritation of eyes and upper respiratory tract.

**CHRONIC HEALTH RISKS:** no reports of systemic injury; may cause exacerbation of symptoms in persons with impaired pulmonary function, especially those with obstructive airway diseases; is a defatting agent and can cause dermatitis on prolonged exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (295 mg/m<sup>3</sup>); OSHA PEL TWA 50 ppm (300 mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (300 mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab-coat, apron or coveralls; use splash-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use clean, non-sparking tools and explosion-proof electrical equipment; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentration, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; a vapor suppressing foam may be used to reduce vapors; absorb liquid with dry earth, sand or other noncombustible materials, and transfer to chemical waste containers; flush remainder with large amounts of water but not into confined spaces such as sewers because of possibility of explosion.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry area; use only with adequate ventilation; outside storage is preferred; inside storage should be in a standard flammable liquid storage room or cabinet; separate from strong oxidants, nitrates, alkalies, and acids.

**REGULATORY INFORMATION:** no information found in the literature but is listed as one of the chemical regulated by the State of California; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used as fragrances in the perfume and cosmetics industry, as components for housefly insecticides, and as chemical components for the large spruce bark beetle attractant; utilized as a solvent for nitrocellulose and other lacquers; this substance has been granted gras status by FDA for food use.

**KEY REFERENCES:** 4; 5; 6; 7; 15.

**HYDRAZINE (H<sub>2</sub>NNH<sub>2</sub>, 32.06)**

**CAS/DOT IDENTIFICATION #:** 302-01-2/UN2029 (anhydrous), UN 2030 (37-64% solution)

**SYNONYMS:** diamide, diamine, hydrazine anhydrous, hydrazine aqueous solutions with >64% hydrazine by weight, hydrazine base.

**PHYSICAL PROPERTIES :** colorless, oily liquid; fumes in air; solid white crystals below 36°F; ammonia-like odor; burns with violet flame; dissolves many inorganic substances; miscible with water, methyl, ethyl, propyl, and isobutyl alcohols; very soluble in water; slightly miscible with hydrocarbons and halogenated hydrocarbons; insoluble in chloroform and ether; forms an azeotropic mixture with water; MP (2.0°C, 35.6°F); BP (113.5°C, 236.3°F); DN (1.0036 g/mL liquid at 25°C); LSG (1.01); ST (66.45 dynes/cm at 25°C); VS (0.913 cP at 25°C); CP (98.9 J/K-mol liquid at 25°C); HV (44.7 kJ/mol at 25°C); VD (1.1); VP (14.4 mmHg at 25°C); OT (3-4 ppm).

**CHEMICAL PROPERTIES:** thermally unstable; powerful reducing agent; strong alkali; reacts vigorously with most oxidizing agents; forms salts with inorganic acids; affected by ultra-violet and metal ion catalysts; highly polar solvent; FP (38°C, 100°F); LFL/UFL (2.9%, 98%); AT (270°C, 518°F on glass surface; 156°C, 313°F on stainless steel; 132°C, 270°F on black iron; 23°C, 74°F on iron rust); HC (-4,633 cal/g, -8345 Btu/lb, -194.1 x 10<sup>5</sup> J/kg); HF (50.6 kJ/mol liquid at 25°C); H<sub>f</sub>(12.6 kJ/mol at 274.5K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 3, Flammability 3, Reactivity 3; thermally unstable; ignites spontaneously on contact with oxidizers or porous materials such as earth, wood and cloth; explodes during distillation if traces of air are present; flashback along vapor trail may occur; vapor may explode if ignited in enclosed area; closed containers may rupture violently upon heating; severe explosion hazard; explodes on contact with barium oxide, calcium oxide, chromate salts, chromium dioxide, mercury oxide, potassium, sodium hydroxide, and silver and titanium compounds; reacts violently with 1-chloro-2,4-dinitrobenzene and oxidants; vigorous reaction with carbon dioxide and stainless steel, copper oxide, lead oxide, potassium peroxodisulfate, and ruthenium (III) chloride; decomposes to ammonia, hydrogen and nitrogen gases on contact with metal catalysts; use dry chemical, alcohol foam, carbon dioxide, or flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and nose, itching, swelling, blistering of eyelids, temporary blindness); ingestion or absorption (nausea, dizziness, headache); contact (caustic-like burns).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin immediately with large amounts of water; provide oxygen or respiratory support; if ingested, wash out mouth with water or give egg whites or other emollient.

**HUMAN TOXICITY DATA:** dna-inhibition-human hela cell 50µmol/L; inhalation unit risk estimate 4.9 x 10<sup>-3</sup> (µg/m<sup>3</sup>)<sup>-1</sup>; EPA Group B2 probable human carcinogen.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; temporary blindness; dizziness; nausea; burns skin and eyes; itching; swelling; blistering of eyelids; headache; pulmonary edema; seizures; death in high concentrations.

**CHRONIC HEALTH RISKS:** damage to liver; lung damage; central nervous system effects; destruction of red blood cells; may alter genetic material; skin sensitization; dermatitis; may cause cancer; reproductive effects; coma.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (skin); OSHA PEL TWA 1 ppm (1.3mg/m<sup>3</sup>)(skin); NIOSH REL CL 0.04 mg/m<sup>3</sup>/2H; IDLH 50 ppm.

**PERSONAL PROTECTION:** wear chemical protective suit with self-contained breathing apparatus; chemical-resistant gloves and safety goggles are recommended; safety showers and eye bath should be provided in the immediate work area.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; use activated carbon and copper ion catalysts to remove hydrazine from wastewater; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dilute to at least 40% and neutralize with dilute sulfuric acid; flush with large amounts of excess water to sewer; dissolve in large volume of flammable solvent and burn in an open pit; detached storage is preferred; inside storage should be in a standard flammable liquids storage room or cabinet; normally stored under nitrogen; water should be provided for flushing spills or leaks; tanks should be located in water-filled dikes; can be stored for years if sealed in glass and kept in a cool, dark place; separate from acids, oxidizing materials, and metal oxides.

**REGULATORY INFORMATION:** CA2; R4; R7; R8; U waste # (U133); Reportable Quantity (RQ): 1 lb (.454kg); Sf1; Sf2; Sf3; A1; CAL; DOT hazard class/division (3); labels (flammable liquid, poison, corrosive)

**OTHER COMMENTS:** used as a chemical intermediate in the manufacture of agricultural chemicals, spandex fibers and antioxidants; used as a reducing agent in electrodeless nickel plating and in plutonium extraction from reactor waste; used as a rocket propellant.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 19.

## **HYDROGEN BROMIDE (HBr, 80.92)**

**CAS/DOT IDENTIFICATION #:** 10035-10-6/UN1048 (anhydrous), UN 1788 (solution).

**SYNONYMS:** anhydrous hydrogen bromide, aqueous hydrogen bromide, hydrobromic acid.

**PHYSICAL PROPERTIES :** colorless gas or pale yellow to brown liquid; sharp irritating odor; fumes in moist air forming clouds which have a sour taste; freely soluble in water; soluble in organic solvents; also soluble in alcohol; often used in an aqueous solution; MP (-86.9°C, -124.4°F); BP(-66.8°C, -88.2°F); DN(2.71 g/mL liquid at 20°C, 3.50 g/L gas at 0°C); LSG (2.7); CP(29.1 J/K-mol gas at 25°C); HV (51.3 cal/g at -66.8°C); VD(3.5); VP(20 atm at 20°C).

**CHEMICAL PROPERTIES:** corrosive, nonflammable gas; highly corrosive to most metals; strong acid; reacts with strong oxidizers, strong caustics, moisture, copper, brass, and zinc; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-36.3 kJ/mol gas at 25°C); H<sub>f</sub> (7.44 cal/g at -86.9°C).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating Health 3, Flammability 0, Reactivity 0; poisonous gas; reacts violently with fluorine, iron (III) oxide, ammonia, and ozone; reaction with water or steam emits toxic and corrosive fumes of Br<sup>-</sup>; decomposes in a fire to produce irritants and toxic gases, use flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (wheezing, coughing, laryngitis, headache, irritates eyes, skin and nose); ingestion (nausea, vomiting, burning of throat).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin immediately with large amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and throat; destructive to tissues of mucous membranes; burning sensation; wheezing; coughing; laryngitis; headache; nausea; vomiting; skin and eye burns.

**CHRONIC HEALTH RISKS:** no data available on chronic health risks in humans; target organs: eyes, skin respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 3 ppm; OSHA PEL TWA 3 ppm (10mg/m<sup>3</sup>); OSHA PEL CL 3 ppm; NIOSH REL CL 3 ppm (10mg/m<sup>3</sup>); IDLH 30 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, cold-insulating gloves, lab coat, apron or coveralls; wear chemical safety goggles; a closed system of local exhaust ventilation is recommended, as well as self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate danger area; remove gas with fine water spray; water jet should never be directed on liquid; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** turn leaking cylinder up to prevent escape of gas in liquid state; use fine water spray to disperse vapors; store in a cool, dry location; maintain adequate ventilation along the floor; separate from incompatible materials.

**REGULATORY INFORMATION:** A5; CAL; DOT hazard class/division (8); labels (corrosive) (UN 1788) DOT hazard class/division (2.3); labels (poison gas, corrosive) (UN 1048).

**OTHER COMMENTS:** used in the manufacture of organic and inorganic bromides; used in the manufacture of hydrobromic acid; used as a reducing agent and as catalyst in controlled oxidations; used in the alkylation of aromatic compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 14.

## **HYDROGEN CHLORIDE(HCl, 36.5)**

**CAS/DOT IDENTIFICATION #:** 7647-01-0/UN1050 (anhydrous), UN2186 (refrigerated liquid)

**SYNONYMS:** anhydrous hydrogen chloride, aqueous hydrogen chloride, hydrochloric acid, muriatic acid

**PHYSICAL PROPERTIES :** colorless to slightly yellow gas; shipped as a liquefied compressed gas; soluble in methanol, ethanol, ether, benzene, and water; pungent, irritating odor; MP (-114°C, -174°F); BP(-85°C, -121°F); DN (1.045 g/cm<sup>3</sup> at -155°C, 0.630 g/cm<sup>3</sup> at 46°C); LSG (1.19 at -85°C); ST (23 dynes/cm at -155°C); CP (0.1375 cal/g/°C at 15°C); HV (3860 cal/mole at -85°C); VD (1.26); VP (3.23 psi at 21.1°C, 7.93 psi at 37.7°C).

**CHEMICAL PROPERTIES:** highly corrosive to most metals; fumes in air; anhydrous hydrogen chloride forms corrosive hydrochloric acid upon rapid absorption in water; aqueous

## 670 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

hydrochloric acid solutions react vigorously with alkalies, strong oxidizers, amines, and most metals; HF (-22.063 kcal/mole gas at 25°C); DE (431.62 kJ at 25°C).

**EXPLOSION and FIRE CONCERNS:** corrosive; NFPA rating Health 3, Flammability 0, Reactivity 1; reacts explosively with alcohol and hydrogen cyanide, potassium permanganate, sodium, and tetraselenium tetranitride; reacts violently with 1,1-difluoroethylene; reacts vigorously with aluminum, alkalies, and chlorine and dinitroaniline; ignites on contact with fluorine, hexalithium disilicide, metal acetylides or carbide; dangerous reaction with sulfuric acid emits hydrogen chloride gas; exothermic reaction upon adsorption of the acid onto silicon dioxide; incompatible with most metals, including copper, brass, and zinc; use water spray or other suitable agent for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose throat, and larynx); contact (liquid frostbite).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with copious amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 1300 ppm/30M; inhalation-human LCLo 3000 ppm/5M; unreported-man LDLo 81 mg/kg.

**ACUTE HEALTH RISKS:** irritation of nose, throat, and larynx; coughing; choking; wheezing; hoarseness; burning sensation; eye and skin burns; labored breath; headache; nausea; vomiting; dental discoloration and erosion; inflammation of the respiratory tract.

**CHRONIC HEALTH RISKS:** destructive to mucous membrane tissues, upper respiratory tract, eyes, and skin; inflammation of the larynx and bronchi; chemical pneumonitis; pulmonary edema; spasms; gastritis; dermatitis; may damage vision.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 5 ppm; OSHA PEL CL 5 ppm (7 mg/m<sup>3</sup>); NIOSH REL CL 5 ppm (7mg/m<sup>3</sup>); IDLH 50 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical resistant rubber gloves; wear chemical safety goggles; wear self-contained breathing apparatus; an 8 inch face shield is also recommended.

**SPILL CLEAN-UP:** use water fog or spray to knock down and absorb vapors; control runoff and properly dispose of discharged material.

**DISPOSAL AND STORAGE METHODS:** dilute with the addition of ice water; quench or neutralize with chemically basic substance such as lime or soda ash; route to sewage plant; store in a cool, dry place; isolate from strong oxidizers, most metals, organic materials, and alkalies, aqueous solutions should be stored in glass bottles and in rubber-line tankers; store anhydrous hydrogen chloride in steel cylinders.

**REGULATORY INFORMATION:** R6; Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sf1; Sf2; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, corrosive).

**OTHER COMMENTS:** used in the manufacture of pharmaceutical hydrochlorides, alkyl chlorides for olefins, and vinyl chloride from acetylene; used in the chlorination of rubber and for making chlorine; used in isomerization, polymerization, and alkylation reactions; used in the cleaning of membranes in desalination plants.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 12; 13; 14; 19.

**HYDROGEN CYANIDE (HCN, 27.0)**

**CAS/DOT IDENTIFICATION #:** 74-90-8/UN1051 (anhydrous), UN1614 (absorbed in a porous material)

**SYNONYMS:** carbon hydride nitride (chn), formonitrile, hydrocyanic acid, prussic acid.

**PHYSICAL PROPERTIES :** colorless or pale-blue liquid or gas (above 78°F); frequently used as a 96% solution in water; bitter, almond-like odor; very weak acid (does not redden litmus); burns in air with a blue flame; bitter, burning taste; miscible in water and alcohol; slightly soluble in ether; MP (-13.4°C, 7.88°F); BP (25.6°C, 78.1°F); DN (0.699 g/mL liquid at 22°C, 0.901 g/L gas); LSG (0.69); VS (0.183 mPa-s at 25°C); CP (70.6 J/K-mol liquid at 25°C); HV (444 Btu/lb, 247 cal/g, 10.3 x 10<sup>3</sup> J/kg); VD (0.932); VP (630 mmHg at 20°C); OT (1 x 10<sup>-3</sup> mg/L).

**CHEMICAL PROPERTIES:** weak acid; water solutions of hydrogen cyanide causes carbon steels to crack under stress even at room temperature; water solutions of hydrogen cyanide containing sulfuric acid severely corrode stainless steels above 80°C and steels above 40°C; solution is light sensitive; can polymerize at 122-140°F; FP (-18°C, 0°F); LFL/UFL (5.6%, 40.0%); AT (540°C, 1004°F); HC (-10,560 Btu/lb, -5,864 cal/g, -245.3 x 10<sup>5</sup> J/kg); HF (108.9 kJ/mol liquid at 255°C); H<sub>f</sub>(8.41 kJ/mol at 259.7K).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 4, Flammability 4, Reactivity 2; burns in air with a blue flame; very dangerous fire hazard; may polymerize explosively at 122-140°F or in the presence of traces of alkali; severe explosion hazard when subjected to chemical reaction with oxidizers; gas forms explosive mixtures with air; reacts violently with acetaldehyde; flashback along vapor trail may occur; vapor may explode if ignited in confined area; closed containers may rupture violently when heated; reaction with water, steam, acid, or acid fumes emits toxic fumes of CN<sup>-</sup>; incompatible with amines, strong oxidizers, acids, sodium hydroxide, calcium hydroxide, sodium carbonate, water, caustics, and ammonia; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cyanosis, headache, dizziness, unsteadiness of gait, feeling of suffocation, asphyxia); absorption (nausea, vomiting, paralysis, convulsions, unconsciousness).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin immediately with large amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 570µg/kg; inhalation-human LCLo 200ppm/15M; inhalation-human LCLo 120mg/m<sup>3</sup>/1H; inhalation-human LCLo 200mg/m<sup>3</sup>/10M; inhalation-man LCLo 400 mg/m<sup>3</sup>/2M; inhalation-man TCLo 500mg/m<sup>3</sup>/3M; subcutaneous-human LDLo 1mg/kg; intravenous-human LD<sub>50</sub> 1mg/kg; intravenous-man TDLo 55µg/kg; toxic effect: pulmonary system; unreported-man LDLo 1471µg/kg.

**ACUTE HEALTH RISKS:** tachypnea, difficulty in breathing; paralysis; headache; confusion; nausea; vomiting; increased rate and depth of respiration; respiratory arrest; vertigo; palpitation; salivation; cyanosis; dizziness; unsteadiness of gait; feeling of suffocation; presence of cherry-red blood; inability of tissues to remove oxygen from the blood; giddiness; collapse; convulsions; death by asphyxia.

**CHRONIC HEALTH RISKS:** fatigue; weakness of arms and legs; thyroid effects; blood changes; toxic effect: central nervous system, cardiovascular system, thyroid, blood.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 4.7 ppm (skin); OSHA PEL TWA 10 ppm (11mg/m<sup>3</sup>)(skin); OSHA PEL STEL 4.7 ppm (skin); NIOSH REL STEL 4.7 ppm(5mg/m<sup>3</sup>)(skin); NIOSH REL CL 5 mg(CN)/m<sup>3</sup>/10M; IDLH 50 ppm.

**PERSONAL PROTECTION:** wear gas-tight rubberized or plasticized protective garments and shoes; wear self-contained breathing apparatus and chemical safety goggles; emergency showers and eyewash fountains should be provided in the immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; stop flow of gas if possible; if leak cannot be stopped, allow to empty in open air in a safe place; use vapor-suppressing foam to blanket release; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** neutralize with caustic and chlorinate; treat with calcium hypochlorite; route to sewage plant or neutralize with caustic and add ferrous sulfate; pour insoluble solid wastes on dry sand and ignite; store in a cool, dry location; shelf-life should not exceed 90 days; store in steel cylinders; also dissolved or absorbed into water, inert solutions, or other materials.

**REGULATORY INFORMATION:** F2; F7; R4; R6; P waste # (P063); Reportable Quantity (RQ): 10 lbs (4.54kg); Sf1; Sf3; CW1; CW2; A5; CAL; DOT hazard class/division (6.1); labels (poison)(UN1614); DOT hazard class/division (6.1); labels (poison, flammable liquid)(UN1051).

**OTHER COMMENTS:** intermediate for methyl methacrylate, sodium cyanide and aminopolycarboxylic acid chelating agents; used as a starting material for nylon 66; used in the manufacture of acrylates, cyanide salts, dyes, rodenticides, and pesticides; also used in the production of synthetic fibers or plastics; useful in the production of cyanide salts for extracting metals, electroplating, hardening of metals and photography.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 14.

## HYDROGEN FLUORIDE(HF, 20.01)

**CAS/DOT IDENTIFICATION #:** 7664-39-3/UN1052

**SYNONYMS:** anhydrous hydrofluoric acid, fluorhydric acid, HFA, hydrofluoric acid gas

**PHYSICAL PROPERTIES :** clear, colorless liquid or gas; strong, irritating odor; very soluble in water and alcohol; soluble in many organic solvents (in benzene, toluene, meta-xylene, and tetralin); slightly soluble in ether; MP (-83°C, -117°F); BP (20°C, 67°F); DN (0.901 g/L gas at 22°C, 0.699 g/L liquid at 22°C); LSG(0.99 at 20°C); HV (1.8 kcal/mole); VD (0.69); VP (400 mmHg at 2.5°C, 760 mmHg at 20°C); OT (0.5-3 ppm).

**CHEMICAL PROPERTIES:** very corrosive to metals; will attack glass and concrete; reacts to form hydrogen gas on contact with metals; fumes in air; reacts with most metals, water or steam; HF (-71.65 kcal/mol at 25°C); H<sub>f</sub> (1094 cal/gmole).

**EXPLOSION and FIRE CONCERNS:** not combustible, but extremely irritating if involved in a fire; combination with water evolves heat; NFPA rating Health 4, Flammability 0, Reactivity 1; reacts explosively with cyanogen fluoride, glycerol and nitric acid, and methanesulfonic acid; violent reaction with acetic anhydride, 2-aminoethanol, chlorosulfonic acid, ethylene diamine, propylene oxide, vinyl acetate, sodium hydroxide, and sulfuric acid; liquid hydrogen fluoride reacts incandescently with arsenic trioxide and calcium oxide; reacts with water or steam to produce toxic and corrosive fumes; incompatible with most metals, water and alkali

materials; decomposition emits highly toxic fumes of F; use flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (pulmonary edema, severe eye and skin burns); contact (pain, visible damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with copious amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 50ppm/30M; inhalation-man TCLo 100mg/m<sup>3</sup>/1M; toxic effect: nose, eye, pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; pulmonary edema; skin and eye burns; nasal congestion; bronchitis; bone changes; coughing; wheezing; labored breath; headache; nausea; vomiting.

**CHRONIC HEALTH RISKS:** target organs: eye, skin, respiratory system, liver, kidney and bones.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 3ppm; OSHA PEL TWA 3 ppm; OSHA PEL STEL 6 ppm; NIOSH REL TWA 3 ppm (2.5 mg/m<sup>3</sup>); NIOSH REL CL 6 ppm (5 mg/m<sup>3</sup>); IDLH 30 ppm.

**PERSONAL PROTECTION:** wear long rubber aprons, long rubber gauntlets, high rubber boots, and wide plastic face shield; wear plastic lensed eye goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray or fog to knock down and absorb vapors; if in liquid form, absorb in noncombustible material or allow to vaporize, and disperse the gas.

**DISPOSAL AND STORAGE METHODS:** neutralize small quantities in trenches and burn; vent fumes through absorption equipment and add to soda ash-slaked lime solution; add neutralized solution to excess running water and route to sewage plant; store in a cool, dry location separate from silica, concrete, glass, ceramics, and incompatible metals; glass containers are not recommended even for dilute solutions.

**REGULATORY INFORMATION:** CA2; R4; U waste # (U134); Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf1; Sf2; Sf3; A2; A5; CAL; DOT hazard class/division (8); labels (corrosive, poison).

**OTHER COMMENTS:** used as a catalyst in the petroleum industry (in the alkylation of paraffins); used in fluorination processes, as in the aluminum industry; used in the manufacture of fluorides; used for separating isotopes of uranium; used in dye chemistry.

**KEY REFERENCES:** 3; 4; 5; 6; 9; 10; 11; 12; 14; 19.

## HYDROGEN PEROXIDE (H<sub>2</sub>O<sub>2</sub>, 34.02)

**CAS/DOT IDENTIFICATION #:** 7722-84-1/UN2014

**SYNONYMS:** dihydrogen dioxide, dihydrogen peroxide, high-strength hydrogen peroxide, hydrogen peroxide, hydrogen dioxide, hydrogen peroxide (aqueous), hydroperoxide, peroxide.

**PHYSICAL PROPERTIES** : colorless, heavy liquid; pure compound is a crystalline solid below 12°F; often used in an aqueous solution; slightly sharp odor; bitter taste; soluble in ether; insoluble in petroleum ether; miscible with water; MP(-0.43°C , 31.2°F); BP(152°C, 305.6°F); DN(1.71 g/mL at -20°C, 1.46 g/mL at 0°C); LSG (1.39); CP(89.1 J/K-mol liquid at 25°C); HV (51.6 kJ/mol at 25°C); VD(NA); VP(1 mmHg at 15.3°C).

**CHEMICAL PROPERTIES** unstable liquid; distillable in high vacuum; powerful oxidizer, particularly in the concentrated state; reacts with alkalis, oxidizable materials, finely divided metals, alcohols, and permanganates; presence of mineral acid makes it more stable; very corrosive; FP (NA); LFL/UFL (NA); AT (NA); HC(NA); HF (-187.8 kJ/mol liquid at 25°C)  $H_f$  (12.5 kJ/mol at 272.72K).

**EXPLOSION and FIRE CONCERNS**: noncombustible liquid, but a powerful oxidizer; NFPA rating Health 2, Flammability 0, Reactivity 3; dangerous fire hazard by chemical reaction with flammable materials; contact with combustible material may result in spontaneous combustion; decomposition is accelerated by agitation or contact with rough surfaces, metals, or many other substances; rapidly decomposed by alkalis and finely divided metals; explodes on contact with alcohols + sulfuric acid, acetal + acetic acid + heat, aromatic hydrocarbons + trifluoroacetic acid, tert-butanol + sulfuric acid, 3,5-dimethyl-3-hexanol + sulfuric acid, carboxylic acid, and many others; contact with hydrogen + palladium catalysts has caused major industrial explosions; forms unstable explosive products in reaction with acetaldehyde and desiccants, acetic anhydride, alcohols, carboxylic acids, diethyl ether, and acetone (forms explosive peroxides); ignites on contact with furfuryl alcohol, powdered metals, and wood; reacts violently with aluminum isopropoxide + heavy metal salts, charcoal, coal, hydrogen selenide, and some metals (e.g., potassium, sodium, and lithium); aqueous solutions between 96 wt% and 100 wt% hydrogen peroxide have been found to have a detonation velocity of about 6500 meters/second; use flooding quantities of water, dry chemical, alcohol foam, or carbon monoxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (irritates eyes, nose and throat); contact (blistering of the skin, skin reddening, bleaching of hair, corneal ulceration).

**FIRST AID**: wash eyes immediately with large amounts of water for several minutes; flush affected areas of skin with large amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA**: oral-man LDLo 1429 mg/kg; oral woman TDLo 1200 mg/kg; dna damage-human other cell types 100µmol/L; dna inhibition-human other cell types 1200 µmol/L; cytogenetic-human embryo 20 µmol/L; other-human embryo 50 µmol/L.

**ACUTE HEALTH RISKS**: irritation of eyes, nose, and throat; erythema; corneal ulceration; vesicles on skin; bleaching of hair; irritating to body tissue.

**CHRONIC HEALTH RISKS**: severe irritation of skin and eyes; may alter genetic material; possible human carcinogen; target organs: eyes, skin, respiratory system.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 1ppm; OSHA PEL TWA 1ppm (1.4 mg/m<sup>3</sup>); NIOSH REL TWA 1 ppm (1.4 mg/m<sup>3</sup>); IDLH 75 ppm.

**PERSONAL PROTECTION**: wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles or face shield; a system of local exhaust ventilation is recommended, as well as self-contained breathing apparatus.

**SPILL CLEAN-UP**: ventilate area of spill or leak; wash away spilled liquid with plenty of water; do not absorb in saw-dust or other combustible absorbents.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in accordance with federal, state, and local regulations; store in a cool location; keep in the dark; store only if stabilized; store in vented containers; separate from combustible and reducing substances, strong bases and metals.

**REGULATORY INFORMATION:** Sf2; A1; A5; CAL; DOT hazard class/ division (5.1); labels (oxidizer, corrosive).

**OTHER COMMENTS:** marketed as a solution in water in concentrations of 3-90% by weight; 90% solution is used in rocket propulsion; used as dough conditioner and as a maturing and bleaching agent in food; useful as a topical antiseptic and cleansing agent.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 14.

## **HYDROGEN SELENIDE (H<sub>2</sub>Se, 80.98)**

**CAS/DOT IDENTIFICATION #:** 7783-07-5/UN2202

**SYNONYMS:** dihydrogen selenide, electronic e-2, hydrogen selenide (anhydrous), selenium dihydride, selenium hydride.

**PHYSICAL PROPERTIES:** colorless gas; odor resembling decayed horse radish; liquefies at 0°C under a pressure of 6.6 atm and at 18°C under a pressure of 8.6 atm; soluble in carbonyl chloride, carbon disulfide and phosgene; soluble in water; MP (-66°C, -87°F); BP(-41.3°C, -42.3°F); DN (3.614g/L gas, 2.12 g/mL liquid at -42°C); CP (34.7 J/K-mol gas at 25°C); HV (19.7 kJ/mol at 231.90K); VD(2.80); VP(1.75 atm at -30°C, 4.5 atm at 0.2°C, 12 atm at 30.8°C, 20 atm at 25.5°C); OT (~0.3 ppm).

**CHEMICAL PROPERTIES:** unites directly with most metals to form metal selenides; conducts electricity and rectifies alternating current; reacts vigorously with strong oxidizers, acids, water, and halogenated hydrocarbons; FP (not applicable); LFL/UFL (NA); AT (NA); HC (NA); HF (29.7 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable gas; dangerous fire hazard when exposed to heat or flame; forms dangerous explosive mixtures with air; will react strongly with powerful oxidizing agents, such as hydrogen peroxide and nitric acid; use agent suitable for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, and throat); contact (nausea, vomiting, diarrhea, garlic breath, metallic taste, dizziness, weakness).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; nausea; vomiting; diarrhea; garlic breath; metallic taste; dizziness; lassitude; fatigue; conjunctivitis; destructive to tissues of mucous membranes.

**CHRONIC HEALTH RISKS:** central nervous system effects; allergic effects; damage to the lungs; liver damage; very little data is available on possible chronic effects in humans, but it is assumed that when the concentration of this gas is low enough to avoid irritant effects, only systemic effects will be noticeable.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05 ppm; OSHA PEL TWA 0.05 ppm (0.2mg/m<sup>3</sup>); NIOSH REL TWA 0.05 ppm (0.2 mg/m<sup>3</sup>); IDLH 1 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, cold-insulating gloves, lab coat, apron or coveralls; wear chemical safety goggles; a closed system of local exhaust ventilation is recommended, as well as self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate danger area; remove gas with fine water spray; water jet should never be directed on liquid; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** turn leaking cylinder up to prevent escape of gas in liquid state; use fine water spray to disperse vapors; store in a cool, dry location; maintain adequate ventilation along the floor; separate from incompatible materials.

**REGULATORY INFORMATION:** Sf2; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, flammable gas).

**OTHER COMMENTS:** prepared by heating selenium and hydrogen in a sealed tube at 440°C, by passing a mixture of hydrogen and selenium vapor over pumice stone at 440°C, or by warming potassium or ferrous selenide with hydrochloric acid.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

## HYDROGEN SULFIDE (H<sub>2</sub>S, 34.08)

**CAS/DOT IDENTIFICATION #:** 7783-06-4/UN1053

**SYNONYMS:** dihydrogen sulfide, hydrogen sulfuric acid, hydrosulfuric acid, sewer gas, sulfuretted hydrogen, sulfur hydride.

**PHYSICAL PROPERTIES :** colorless gas; strong odor of rotten eggs; sweetish taste; burns in air with pale blue flame; soluble in glycerol, gasoline, kerosene, carbon disulfide, and crude oil; soluble in water; MP (-86°C, -122°F); BP(-60°C, -76°F); DN(1.5392 g/L liquid at 0°C and 760 mmHg); LSG (1.54); VS (12.6μPa-s at 25°C); CP(34.2 J/K-mol gas at 25°C); HV (14.08 kJ/mol at 25°C); VD(1.189); VP(14,060 mmHg at 20°C); OT (0.02-0.13 ppm).

**CHEMICAL PROPERTIES** water solutions of hydrogen sulfide are unstable; absorbed oxygen causes the formation of elemental sulfur, and the solutions become turbid rapidly; reacts with strong oxidizing materials, strong nitric acid, and metals; FP (not applicable); LFL/UFL (4.3%, 46.0%); AT (260°C, 500°F); HF (-20.6 kJ/mol gas at 25°C) H<sub>f</sub> (23.8 kJ/mol at 187.6K).

**EXPLOSION and FIRE CONCERNS:** flammable gas; NFPA rating Health 4, Flammability 4, Reactivity 0; forms explosive mixtures with air over wide range; very dangerous fire hazard when exposed to heat, flame, or oxidizing materials; moderately explosive; explodes on contact with oxygen difluoride, nitrogen trichloride, chlorine trifluoride, dichlorine oxide, and bromine pentafluoride; reacts explosively when heated with perchloryl fluoride (above 100°C) and oxygen (above 280°C); ignites on contact with metal oxides, such as barium peroxide, chromium trioxide, copper oxide, lead dioxide, manganese dioxide, nickel oxide, sodium peroxide, mercury oxide, calcium oxide, and oxides of silver; violent reactions with nitrogen trifluoride, oxygen difluoride, fluorine, copper, chlorine oxide, acetaldehyde, and bromine pentafluoride; combustion produces highly toxic fumes of oxides of nitrogen; use water spray, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (salivation, gastrointestinal disturbances, giddiness, headache, vertigo, confusion, elevated heartbeat, sweating, fatigue); contact (conjunctivitis, lacrimation, corneal opacity, rhinitis, laryngitis, coughing, bronchitis, pneumonia, erythema, skin irritation).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash skin immediately with large amounts of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 600ppm/30M; inhalation-human LCLo 800ppm/5M; inhalation-man LDLo 5700µg/kg; toxic effect: central nervous system, pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; conjunctivitis; photophobia; lacrimation; corneal opacity; tearing, pain, and blurred vision; rhinitis; bronchitis; coughing; broncho-pneumonia; skin irritation; erythema; laryngitis; salivation; gastrointestinal disturbances; giddiness; headache; vertigo; confusion; unconsciousness; tachycardia; sweating; fatigue; tachypnea; paralysis of respiratory center; apnea; sudden collapse; death by asphyxiation.

**CHRONIC HEALTH RISKS:** headache; inflammation of eyelids and conjunctivae; digestive disturbances; weight loss; general debilitation.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm; ACGIH TLV STEL 15 ppm; OSHA PEL TWA 10ppm; OSHA PEL STEL 15 ppm; OSHA PEL CL 20 ppm; OSHA PEL CL 50 ppm (10-minute maximum peak); NIOSH REL CL 15 mg/m<sup>3</sup>/10M; IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, cold-insulating gloves, lab coat, apron or coveralls; wear chemical safety goggles; a closed system of local exhaust ventilation is recommended, as well as self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; evacuate danger area; remove gas with fine water spray; water jet should never be directed on liquid; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** turn leaking cylinder up to prevent escape of gas in liquid state; use fine water spray to disperse vapors; store in a cool, dry location; maintain adequate ventilation along the floor; separate from incompatible materials.

**REGULATORY INFORMATION:** CA2; R4; R6; R8; U waste# (U135); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf2; Sf3; CW1; CW2; A1; A2; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, flammable gas).

**OTHER COMMENTS:** used in the production of elemental sulfur and sulfuric acid; used in the manufacture of heavy water and other chemicals; useful in metallurgy and as an analytical reagent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 14.

## HYDROQUINONE (C<sub>6</sub>H<sub>6</sub>O<sub>2</sub>, 110.12)

**CAS/DOT IDENTIFICATION #:** 123-31-9/UN2662

**SYNONYMS:** p-benzenediol, 1,4-benzenediol, dihydroxybenzene, 1,4-dihydroxybenzene, quinol.

**PHYSICAL PROPERTIES** : colorless, hexagonal prisms; white crystals; needles from water; sweet taste; very soluble in alcohol and ether; slightly soluble in benzene; also very soluble in carbon tetrachloride; practically insoluble in water; MP (170-171°C, 338-340°F); BP (285-287°C, 545-548.6°F); DN (1.332 g/mL at 20°C); LSG (1.33); VD (3.81); VP (1 mmHg at 132.4°C, 4mmHg at 150°C).

**CHEMICAL PROPERTIES**: combustible solid; rapid oxidation in presence of alkali and light; solution becomes brown in air and oxidizes to quinone; FP (165°C, 329°F); AT (515.6°C, 960°F).

**EXPLOSION and FIRE CONCERNS**: combustible when exposed to heat or flame; NFPA rating Health 2, Flammability 1, Reactivity 0; reacts vigorously with strong oxidizers and alkalies; reacts explosively with oxygen at 90°C and 100 bar; reacts violently with sodium hydroxide; slight explosion hazard when exposed to heat; use carbon dioxide, dry chemical, or water for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (irritates eyes, breathing difficulty); ingestion (ringing in the ears, nausea, vomiting, dizziness, suffocation); contact (dermatitis, ulceration of the cornea).

**FIRST AID**: wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA**: oral-human TDLo 170mg/kg; toxic effect: central nervous system, cardiovascular, pulmonary; oral-human LDLo 29mg/kg; sce-human lymphocyte 5µmol/L; oms-human lymphocyte 5µmol/L; skin-human 2% mild irritation effects; skin-human 5% severe irritation effects; oms-human lymphocyte 5µmol/L.

**ACUTE HEALTH RISKS**: irritation of eyes; discoloration of conjunctiva; corneal changes; nausea; dizziness; suffocation; rapid respiration; vomiting; pallor; muscle twitching; headache; delirium; collapse; skin irritation; inflammation of the cornea; colored urine (green or brownish green); death.

**CHRONIC HEALTH RISKS**: anemia; allergic reactions; central nervous system excitement; loss of skin pigment; dermatitis; carcinogen; target organs: eyes, skin, respiratory system, central nervous system.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 2 mg/m<sup>3</sup>; OSHA PEL TWA 2mg/m<sup>3</sup>; NIOSH REL CL 2mg/m<sup>3</sup>/15M; IDLH 50mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP**: sweep up material, place in a suitable container, and hold for waste disposal; evacuate area and avoid dust clouds; flush with large amounts of water and disperse, but not into water intakes or confined spaces such as sewers; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS**: mix liquid with a flammable solvent, and atomize large amounts in a suitable combustion chamber; dissolve solid in flammable solvent and spray into incinerator; store in a cool, dry location, under nitrogen; keep containers tightly sealed and separate from strong oxidizers and alkalies.

**REGULATORY INFORMATION**: CA2; Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf2; Sf3; T120-a; T799-18; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a photographic reducer and developer; used to inhibit polymerization; used in pharmaceuticals to treat skin blemishes; used as a stabilizer in paints and varnishes.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 14; 19.

### **IODINE (I<sub>2</sub>, 253.81)**

**CAS/DOT IDENTIFICATION #:** 7553-56-2/UN1759

**SYNONYMS:** iodine crystals, iodine sublimed, molecular iodine.

**PHYSICAL PROPERTIES :** bluish-black crystals; metallic luster; pungent odor; sharp, acrid taste; readily sublimates to a violet vapor; soluble in alcohol, carbon disulfide, chloroform, glacial acetic acid, glycerol oils, carbon tetrachloride, ethyl ether, benzene, and other organic solvents; freely soluble in aqueous solutions of hydrogen iodide (HI) or iodides; slight water solubility; depending on the concentrations of the iodine, solutions of iodine in aqueous solutions of inorganic iodides are brown or deep brown; will dissolve in solvents containing nitrogen atoms (such as pyridine, amines, or quinoline), to form brown solutions; will dissolve in chloroform, carbon tetrachloride, carbon disulfide, and phosphorus trichloride to give violet solutions; solubility in water is increased by alkali bromides, decreased by sulfates and nitrates; MP (114°C, 237°F); BP (184°C, 363°F); DN(4.93 g/cm<sup>3</sup> solid at 25°C); SG (4.98); CP (54.4 J/K-mol crystal at 25°C); HV (41.57 kJ/mol at 457.5K); VD (8.8); VP (0.030 mmHg at 0°C, 0.305 mmHg at 25°C, 2.154 mmHg at 50°C, 26.78 mmHg at 90°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; least reactive of the halogens; low volatility at ordinary room temperatures; reacts vigorously with reducing materials; sodium thiosulfate solution or ammoniated alcohol may remove iodine stains; reacts with ammonium hydroxide to form shock-sensitive iodides on drying; FP (NA); LFL/UFL (NA); AT (NA); HF (0.0 kJ/mol crystal at 25°C, 62.4 kJ/mol gas at 25°C); HC (NA); H<sub>f</sub> (15.52 kJ/mol at 386.8K).

**EXPLOSION and FIRE CONCERNS:** not combustible, but substance is a strong oxidizer; NFPA rating Health 3, Flammability 0, Reactivity 1; its heat of reaction with reducing agents or combustibles may cause ignitions; reaction with acetaldehyde and acetylene can be violent or explosive; forms sensitive, explosive mixtures with potassium, sodium, and oxygen difluoride; ignites on contact with bromine pentafluoride, chlorine trifluoride, fluorine, powdered metals and water, nonmetals (e.g., boron ignites at 700°C), phosphorus, and sodium phosphinate; reacts violently with aluminum and diethyl ether, dipropylmercury, and titanium (above 113°C); reacts incandescently with cesium oxide (above 150°C), bromine trifluoride, calcium acetylide (above 305°C), strontium acetylide (above 182°C), and zirconium acetylide (above 400°C); incompatible with ammonia, powdered metals, alkali metals, ethanol, formamide, halogens (e.g. chlorine), mercuric oxide, oxygen, pyridine, sodium hydride, and sulfides; heating to decomposition emits toxic fumes of I<sup>-</sup> and various iodine compounds; use water spray or any means suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates nose and throat, coughing, tightness of chest, sore throat, headache, delayed pulmonary edema, irritates mucous membranes, lacrimation, discharge of thin nasal mucus); contact (blistering burns, irritation, pain, severe burns and permanent eye damage, cutaneous hypersensitivity); ingestion (nausea, vomiting, diarrhea, abdominal pain, fever, weight loss, stupor, shock).

**FIRST AID:** flush eyes immediately with plenty of water; wash affected areas of skin with plenty of soap and water; immediately wash skin with 5% sodium thiosulfate solution to remove iodine stains; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; observe for the development of pulmonary edema; if ingested, induce vomiting and get immediate medical attention.

**HUMAN TOXICITY DATA:** oral-human LDLo 28mg/kg; toxic effect: gastrointestinal tract; oral-woman TDLo 26mg/kg/1Y-intermittent; toxic effect: systemic effects-effects on the metabolic and excretory functions of the liver or kidneys; unreported-man LDLo 29 mg/kg.

**ACUTE HEALTH RISKS:** irritation of mucous membranes and respiratory tract; tightness in chest; sore throat; headache; delayed pulmonary edema; excessive tears; rhinitis; skin burns; rash; severe burns of the mouth, throat, and stomach; abdominal pain; diarrhea; fever; vomiting; nausea; stupor; shock; purging; excessive thirst; circulatory failure; death in high vapor concentrations.

**CHRONIC HEALTH RISKS:** insomnia; conjunctivitis; inflammation of the nasal mucosa; bronchitis; tremor; rapid heartbeat; diarrhea; weight loss; allergic sensitization; thyroid disease.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 0.1 ppm; OSHA PEL CL 0.1 ppm (1 mg/m<sup>3</sup>); NIOSH REL CL 0.1 ppm (1mg/m<sup>3</sup>); IDLH 2ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, proper gloves, lab coat, apron or coveralls; use chemical safety goggles where splashing is possible; wear self-contained breathing apparatus operated in a positive pressure mode; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect and containerize as much solid iodine as possible; spill area may be covered with an excess of reducing agents (bisulfate, sodium thiosulfate, or ferrous salts in 3M sulfuric acid), and then neutralize with soda ash; collect slurry into approved containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; protect against physical damage; keep in a tightly closed container; keep away from sources of heat or ignition; store separately from reactive or combustible materials, and out of direct sunlight.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used in the manufacture of dyes (aniline dyes, phthalein dyes), iodine compounds (iodides, iodates), antiseptics, and germicides; used to reduce friction of hard surfaces, including glass and stainless steel; also used as an alkylation and condensation catalyst in the preparation of aromatic amines, in sulfonations and sulfations; useful as x-ray contrast media, as stabilizers, food and feed additives, and in water treatment; important reagent in analytical chemistry; has also been used in pharmaceuticals and medicinal soaps; artificial isotopes of iodine are used in biochemical, biological, and chemical structure research.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**IRON OXIDE FUME (Fe<sub>2</sub>O<sub>3</sub>, 159.69).**

**CAS/DOT IDENTIFICATION #:** 1309-37-1/none

**SYNONYMS:** ferric oxide, iron (III) oxide, iron sesquioxide, red iron oxide.

**PHYSICAL PROPERTIES:** red to brown powder; odorless; negligible solubility in water (<0.1%); soluble in acids; insoluble in alcohol and ether; MP(1462°C, 2664°F); BP(unknown); DN(5.24 g/cm<sup>3</sup>); SG (5.24); CP(103.9 J/K-mol crystal at 25°C); VD(not applicable); VP(not applicable).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; incompatible with hydrazine, calcium hypochlorite, and performic acid; FP(not applicable); LFL/UFL (not applicable); AT (not applicable); HC(not applicable); HF(-824.2 kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); not expected to be a fire hazard; no information found concerning explosion hazards; no information found concerning hazardous decomposition products; in case of fire in the surroundings, use extinguishing media appropriate for surrounding fire.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract, benign pneumoconiosis); skin/eye contact (irritates skin and eyes); ingestion (no adverse effects reported).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if breathing has stopped, provide respiratory support; in case of ingestion, give water to drink and get medical advice.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of upper respiratory tract; may cause skin irritation; eye irritation may occur.

**CHRONIC HEALTH RISKS:** overexposure to dust and fumes may cause benign pneumoconiosis with x-ray shadows not distinguishable from fibrotic pneumoconiosis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg/m<sup>3</sup>, welding fumes; OSHA PEL TWA 10 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>, IDLH 2500 mg (as Fe)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; wear chemical safety goggles and/or full face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** carefully sweep up iron oxide dust and remove; if appropriate, moisten first to prevent from dusting; wear suitable protective clothing during clean-up procedures.

**DISPOSAL AND STORAGE METHODS:** dispose in accordance with federal, state, and local regulations; processing, use, or contamination of this product may change the waste management options; suitable for any general chemical storage area; keep container tightly closed.

**REGULATORY INFORMATION:** Al; CAL; DOT hazard class (none).

**OTHER COMMENTS:** exposure to iron oxide fume may occur during the arc-welding of iron; iron oxide may be used as a pigment for rubber paints, paper, ceramics, glass, and linoleum; useful as a polishing agent for diamonds and precious metals; has also been used in the electronic industry (e.g., in electrical resistors and semiconductors); use as a catalyst and as coatings for magnetic tape.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **ISOAMYL ACETATE (C<sub>7</sub>H<sub>14</sub>O<sub>2</sub>, 130.21)**

**CAS/DOT IDENTIFICATION #:** 123-92-2/UN1104

**SYNONYMS:** banana oil, isoamyl ethanoate, isopentyl acetate, 3-methyl-1-butanol acetate, 3-methylbutyl ester of acetic acid, 3-methylbutyl ethanoate.

**PHYSICAL PROPERTIES :** colorless liquid; strong pear, banana-like odor; strong, penetrating, and repulsive odor if impure; strong pear, banana taste; miscible with ethyl acetate, amyl alcohol, fixed oils, ethers, esters, and hydrocarbons; soluble in acetone; slightly soluble in water; insoluble in glycerin and propylene glycol; MP (-78°C, -108°F); BP (143°C, 289°F); DN (0.8670 g/mL at 20°C); LSG (0.87); VS (1.030 cP at 8.97°C, 0.872 cP at 19.91°C); HV (37.53 kJ/mol at 415.70K); VD (4.5); VP (4 mmHg at 20°C); OT (0.017 mg/L in water, 0.025 µl/L in air).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; neutral liquid; hazardous polymerization will not occur; can react vigorously with reducing agents; not compatible with nitrates, strong oxidizers, strong acids and bases; FP (25°C, 77°F); LFL/UFL (1.0%, 7.5%); AT (360°C, 680°F); HC (-14,402 Btu/lb, -8000 cal/g).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid and vapor when exposed to heat or flame; NFPA rating Health 1, Flammability 3, Reactivity 0; explosive vapor/air mixtures may be formed above 25°C; risk of fire and explosion on contact with oxidants; sealed containers may rupture when heated; sensitive to static discharge; incompatible with nitrates, strong oxidizers, strong acids, bases and reducing agents; heating to decomposition emits carbon monoxide and carbon dioxide; use dry chemical, alcohol-resistant foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates the mucous membrane, coughing, labored breath, sore throat, depresses the central nervous system, narcosis, headache, drowsiness, weakness, damage to kidneys, injury to liver and lungs); contact (defatting action of the skin, dermatitis, reddening of eyes); ingestion (nausea, vomiting, abdominal pain, diarrhea, sore throat).

**FIRST AID:** flush eyes with plenty of water for several minutes; flush skin immediately with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; if swallowed, give large quantities of water; do not induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to respiratory tract; sore throat; coughing; shortness of breath; affects central nervous system causing dizziness, incoordination and unconsciousness; narcosis; abdominal pain; nausea; vomiting; diarrhea; drowsiness; headache; weakness; dry skin; irritation to skin, including redness, itching and pain; eye irritation, including redness and pain.

**CHRONIC HEALTH RISKS:** prolonged exposure may cause severe skin irritation or dermatitis; persons with pre-existing skin disorders or eye problems, or impaired liver, kidney or respiratory function may be more highly susceptible to the effects of this substance.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm(532 mg/m<sup>3</sup>); OSHA PEL TWA 100 ppm (525mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (525 mg/m<sup>3</sup>); IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or full face shield where splashing is possible; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); in high vapor concentrations, wear self-contained breathing apparatus; dust/mist pre-filter should be used for the particulate phase since this compound possibly exists in both particulate and vapor phase; use a closed system, ventilation, and explosion-proof electrical equipment above 25°C; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers when possible; absorb remaining liquid with inert materials (e.g., dry sand, earth, vermiculite), and place in a chemical waste container; use water spray to cool and disperse vapors if spill has not ignited; flush spills away from exposures but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent and remove to a secured, sanitary landfill; cautiously ignite small amounts in open areas; atomize large amounts in a suitable combustion chamber; store in a cool, dry, well-ventilated location; outside storage is preferred; containers should be bonded and grounded for transfers to avoid static sparks; use non-sparking type tools and equipment, including explosion proof ventilation; keep away from any area where the fire hazard may be acute and separate from incompatibles.

**REGULATORY INFORMATION:** T30-e10; T120-d10; A1; CAL.

**OTHER COMMENTS:** used as a solvent for old oil colors, for tannins, lacquers, celluloid, nitrocellulose, and camphor; used as a pear flavoring in mineral waters and syrups; useful in masking undesirable odors; also used in the manufacture of artificial silk, photographic films, leather or pearls, waterproof varnishes, metallic paints, celluloid cements, and dyeing and finishing textiles.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 11; 14.

### ISOAMYL ALCOHOL, PRIMARY and SECONDARY (C<sub>5</sub>H<sub>12</sub>O, 88.17)

**CAS/DOT IDENTIFICATION #:** 123-51-3/UN1105

**SYNONYMS:** (Primary) fermentation amyl alcohol, isobutylcarbinol, isopentyl alcohol, 3-methyl-1-butanol, primary isoamyl alcohol; (Secondary) 3-methyl-2-butanol, secondary isoamyl alcohol.

**PHYSICAL PROPERTIES :** clear, colorless liquid; disagreeable odor; pungent, repulsive taste; slightly soluble in water; miscible with alcohol, ether, chloroform, benzene, petroleum ether, oils and glacial acetic acid; (Primary) MP (-117.2°C, -179°F); BP (132°C, 270°F); DN (0.813 g/mL at 15°C); LSG (0.813 at 15°C); ST (23.71 mN/m at 25°C); VS (3.692 mPa-s at 25°C); HV (55.61 kJ/mol at 25°C); VD (3.04); VP (2 mmHg at 20°C); (Secondary) MP (unknown); BP (113°C, 235.4°F); DN (0.819 g/mL at 15°C); LSG (0.82 at 20°C); ST (unknown); VS (unknown); HV (unknown); VD (unknown); VP (1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; heat contributes to instability; hazardous polymerization will not occur; material reacts vigorously with reducing agents; (Primary) FP (43°C, 109°F); LFL/UFL (1.2%, 9.0%); AT (350°C, 662°F); HC (-3.0623 x 10<sup>9</sup> J/kmol); HF (-356.4 kJ/mol liquid at 25°C). (Secondary) FP (35°C, 95°F); LFL/UFL (unknown); AT (unknown); HC (unknown); HF (-366.6 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid and vapor; forms explosive vapor-air mixtures above flash point; NFPA rating Health 1, Flammability 2, Reactivity 0; contact with strong oxidizers may cause fire and explosions; reacts explosively with hydrogen trisulfide; vigorous reaction with reducing materials both vapor and liquid may travel to source of ignition and flashback; carbon dioxide and carbon monoxide may form when heated to decomposition; use alcohol foam, carbon dioxide, dry chemical, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, respiratory changes, headache, dizziness, cough, shortness of breath, nausea, vomiting, diarrhea, narcosis, death); skin contact (irritation, redness, pain, skin cracking); eye contact (severe pain and irritation); ingestion (abdominal pain, vomiting, diarrhea, nausea).

**FIRST AID:** wash eyes with water for several minutes; promptly wash affected areas of skin with mild soap and water; if breathing is difficult, provide oxygen; if not breathing, provide artificial respiration; in case of ingestion, induce vomiting immediately as directed by medical personnel.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 150 ppm; toxic effect: nose, eye, pulmonary system; eye-human 150 ppm.

**ACUTE HEALTH RISKS:** irritation to eyes, nose and throat; irritation of mucous membranes and respiratory tract; headache; dizziness; cough; dyspnea; abdominal pain; nausea; vomiting; diarrhea; narcosis; death.

**CHRONIC HEALTH RISKS:** prolonged or repeated skin contact causes defatting of skin; pre-existing skin disorders, eye problems; impaired liver, kidney or respiratory function may be exacerbated by the effects of this substance.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; ACGIH TLV STEL 125 ppm; OSHA PEL TWA 100 ppm (360 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (360 mg/m<sup>3</sup>); OSHA PEL STEL 125 ppm (450 mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles; use non-sparking type tools and equipment, including explosion proof ventilation; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing apparatus; for extra personal protection a dust/mist prefilter should be used for the particulate phase; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect spilled liquid in sealable containers or absorb with an inert material (e.g., dry earth, sand, vermiculite); flush remaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb with sand or other inert material, and place in a secured, sanitary landfill; dispose of in accordance with federal, state and local

regulations; store in a cool, dry location; use with adequate ventilation; keep container closed; container should be bonded and grounded for transfers to avoid static sparks; outside storage is preferred; isolate from incompatible substances; keep away from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** use as a solvent for resins, fats, alkaloids, etc.; used in the manufacture of isoamyl compounds, lacquers, smokeless powders, artificial silk, mercury fulminate, and pyroxylin; other uses include organic synthesis, preparation of pharmaceutical products, microscopy, and determination of fat in milk.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**ISOBUTYL ACETATE (CH<sub>3</sub>COOCH<sub>2</sub>CH(CH<sub>3</sub>)<sub>2</sub>, 116.18)**

**CAS/DOT IDENTIFICATION #:** 110-19-0/UN1213

**SYNONYMS:** isobutyl ester of acetic acid, 2-methylpropyl acetate, 2-methylpropyl ester of acetic acid, 2-methyl-1-propyl acetate, β-methylpropyl ethanoate.

**PHYSICAL PROPERTIES :** colorless; neutral liquid; fruit-like, floral odor; very soluble in alcohol, fixed oils, and propylene glycol; slightly soluble in water; characteristic ether-like, slightly bitter flavor; banana taste; MP (-98.58°C, -145.4°F); BP (117.2°C, 243°F); DN (0.8712 g/mL at 20°C); LSG (0.87); ST (23.7 dynes/cm at 20°C); HV (133 Btu/lb, 73.7 cal/g, 3.09 x 10<sup>5</sup> J/kg); VD (4.0); VP (10 mmHg at 12.8°C, 40 mmHg at 39.2°C, 100mmHg at 59.7°C, 400 mmHg at 97.5°C); OT (0.64μL/L).

**CHEMICAL PROPERTIES:** flammable liquid; heat may contribute to instability; hydrolyzes to acetic acid and isobutanol upon absorption by the body; low flash point; reacts vigorously with strong oxidizers, nitrates, alkalies, and acids; FP (17.8°C, 64°F); LFL/UFL (1.3%, 10.5%); AT (423°C, 793°F); HC (-13,000 Btu/lb, -7,220 cal/g, -302 x 10<sup>5</sup> J/kg).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; very dangerous fire hazard when exposed to heat, flame or oxidizers; moderate explosion hazard; flashback along vapor trail may occur; may explode if ignited in confined area; incompatible with oxidizing materials, alkalies, acids, and nitrates; heating to decomposition emits toxic vapors and gases, such as carbon monoxide; use alcohol foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, vomiting, dizziness, loss of consciousness, irritates eyes, nose and throat); contact (irritates eyes and may irritate skin).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, upper respiratory system and skin; nausea; vomiting; dizziness; loss of consciousness; lacrimation; narcosis; headache; cough; pain in chest; shortness of breath; fatigue; drowsiness; anesthetic effects.

**CHRONIC HEALTH RISKS:** dermatitis; central nervous system depression.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 150 ppm; OSHA PEL TWA 150ppm (700mg/m<sup>3</sup>); NIOSH REL TWA 150ppm (700mg/m<sup>3</sup>); IDLH 1300 ppm.

**PERSONAL PROTECTION:** wear protective clothing including rubber gloves and boots; safety goggles and self-contained breathing apparatus are recommended.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; absorb as much as possible with materials such as dry earth or sand; flush remaining isobutyl acetate with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** cover contaminated material with a sorbent material such as peat, sawdust, straw, etc.; place all contaminated sorbent and soil in impervious containers; subject to ultimate disposal by controlled incineration; materials may also be buried in a chemical waste landfill; store in a cool, dry, well-ventilated location; separate from strong oxidizers, alkalies, acids and nitrates.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose, in thinners, sealants, and topcoat lacquers; used in non-alcoholic beverages; useful as a flavoring agent in banana, raspberry, strawberry, and butter; employed in the perfume industry.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 12; 13; 14.

### ISOBUTYL ALCOHOL ((CH<sub>3</sub>)<sub>2</sub>CHCH<sub>2</sub>OH, 74.14)

**CAS/DOT IDENTIFICATION #:** 78-83-1/UN1212

**SYNONYMS:** 1-hydroxymethylpropane, isobutanol, isopropylcarbinol, 2-methylpropan-1-ol, 2-methyl-1-propanol.

**PHYSICAL PROPERTIES :** clear, colorless, oily liquid; sweet, musty odor; sweet whiskey taste; miscible with alcohol and ether; slightly soluble in water; MP (-108°C, -162.4°F); BP (10.7.9°C, 226°F); DN (0.800 g/mL at 20°C); LSG (0.80); CP (181.5 J/K-mol liquid at 25°C); LHV (138 cal/g, 248 Btu/lb, 5.78 x 10<sup>5</sup> J/kg); VD (2.55); VP (10 mmHg at 21.7°C); OT (40 ppm).

**CHEMICAL PROPERTIES:** flammable liquid; corrosive; will attack some forms of plastics, rubber, and coatings; heat contributes to instability; reacts with strong oxidizers; FP (28°C, 82°F); LFL/UFL (1.7%, 10.6%); AT (426.7°C, 800°F); HF (-334.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; flashback along vapor trail may occur; dangerous fire hazard; moderately explosive in vapor form when exposed to heat, flame, or oxidizers, vapor may explode if ignited in confined spaces; reacts explosively with aluminum at 100°C to form hydrogen gas; ignites on contact with chromium trioxide; rupture hazard when confined in boiler feed or cooling water; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, dizziness, headache, irritates nose and throat); contact (severe eye irritation, mild irritant to skin, irritates tissues of mucous membranes).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with large amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of eyes and throat; headache; drowsiness; skin irritation; skin cracking; nausea; dizziness; stupor; narcotic effects.

**CHRONIC HEALTH RISKS:** may alter genetic material; questionable carcinogen; target organs: eyes, skin central nervous system, respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; OSHA PEL TWA 100 ppm (300 mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (150 mg/m<sup>3</sup>); IDLH 1600 ppm.

**PERSONAL PROTECTION:** wear impervious clothing such as boots, aprons, sleeves, etc.; chemical resistant gloves are recommended; splash-proof safety goggles and self-contained breathing apparatus are required.

**SPILL CLEAN-UP:** use water spray to dilute and disperse vapors; flush remaining isobutyl alcohol with large amounts of water but not into confined spaces such as sewers because of danger of explosion; absorb small quantities on paper towels and evaporate in fume hood; absorb large quantities with non-combustible materials and atomize in a suitable combustion chamber; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** spray into incinerator or burn in paper packaging; dissolve in additional flammable solvent and burn in incinerator equipped with effluent gas cleaning device; store in a cool, dry location; keep away from heat and open flame; separate from strong oxidizers.

**REGULATORY INFORMATION:** R3; R4; R5; R6; R8; U waste # (U140); Reportable Quantity (RQ): 5000 lbs (2270kg); Sf1; T799-5000; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of isobutyl esters, which serve as plasticizers and in perfumes; useful in the manufacture of esters for fruit flavoring essences; solvent in paint, varnish removers, surface coatings, and adhesives; chemical intermediate for isobutylamines, isobutylacetate and methacrylate esters; used with dimethyl sulfoxide to prepare food additives such as sucrose fatty acid esters.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 11; 12; 13; 14.

## **ISOPHORONE (C<sub>9</sub>H<sub>14</sub>O, 138.23)**

**CAS/DOT IDENTIFICATION #:** 78-59-1/NA

**SYNONYMS:** isoacetophorone, 3,5,5-trimethyl-2-cyclohexenone, 3,5,5-trimethyl-2-cyclohexene-1-one.

**PHYSICAL PROPERTIES :** colorless to water-white liquid; peppermint-like odor; soluble in ether, acetone alcohol, cellulose ester, and vinyl resins; not soluble in water; MP

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(8°C, 17°F); BP (215°C, 419°F); DN (0.9229 g/mL at 20°C); LSG (0.92); VS (2.62 cP at 20°C); VD (4.77); VP (0.3 mmHg at 20°C, 1 mmHg at 38°C); OT (0.2 ppm).

**CHEMICAL PROPERTIES:** combustible liquid; low volatility with oxidizing agents, strong alkalis, and amines; FP (84°C, 184°F); LFL/UFL (0.8%, 3.8%); AT (460°C, 860°F).

**EXPLOSION and FIRE CONCERNS:** flammable and explosive when exposed to heat or flame; NFPA rating Health 2, Flammability 2, Reactivity 0; incompatible with oxidizers, strong alkalis, and amines; use foam, dry chemical, carbon dioxide, or water spray for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory system); ingestion (headache, nausea, dizziness); contact (burning sensation, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCl<sub>o</sub> 25 ppm; toxic effect: nose, eye, pulmonary system; eye-human 25ppm/15M.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and throat; destructive to tissues of mucous membranes; headache; nausea; dizziness; fatigue; malaise; labored breath; bronchitis; coughing; narcosis.

**CHRONIC HEALTH RISKS:** asthma; central nervous system depression; carcinogen; target organs: eyes, skin, liver, kidneys, respiratory system, central nervous system.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 5 ppm; OSHA PEL TWA 25 ppm (140 mg/m<sup>3</sup>); NIOSH REL TWA 4 ppm (23 mg/m<sup>3</sup>); IDLH 200 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** stop or control leak; use water spray to cool and disperse vapors; properly dispose of discharged material.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; cautiously ignite small amounts in open area; atomize large amounts in a suitable combustion chamber equipped with afterburner and scrubber; store in a cool, dry place; outside storage is preferred; separate from oxidizing materials.

**REGULATORY INFORMATION:** CA2; S3; R3; R5; Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sfl; CW3; CW4; CW5; T120-a; A1; CAL; DOT hazard class/division (NA).

**OTHER COMMENTS:** used as a solvent in some printing inks, lacquers, paints, and adhesives; used in the manufacture of pesticides, polyvinyl and nitrocellulose resins, and gasoline.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 12; 14; 19.

### ISOPROPYL ACETATE (CH<sub>3</sub>COOCH(CH<sub>3</sub>)<sub>2</sub>, 102.15)

**CAS/DOT IDENTIFICATION #:** 108-21-4/UN1220

**SYNONYMS:** 2-acetoxypropane, isopropyl ester of acetic acid, isopropyl ethanoate, 1-methylethyl ester of acetic acid, 2-propyl acetate.

**PHYSICAL PROPERTIES** : colorless liquid; fruity, aromatic odor; miscible with alcohol, ether, and fixed oils; soluble in acetone; slightly soluble in water; MP (-73.4°C, -100.1°F); BP(90°C, 194°F at 760 mmHg); DN (0.8718 g/mL at 20°C); LSG (0.87); ST (26 dynes/cm at 20°C); VS (0.49 cP at 25°C); CP (199.4 J/K-mol liquid at 25°C); HV (150 Btu/lb, 81 cal/g,  $3.4 \times 10^3$  J/kg); VD (3.52); VP (59.2 mmHg at 25°C); OT (2.7µL/L).

**CHEMICAL PROPERTIES**: flammable liquid; hydrolyzes upon standing to produce acetic acid and isopropanol; reacts with nitrates, strong oxidizers, alkalies, and acids; FP (2.2°C, 36°F); LFL/UFL (1.8%, 8.0%); AT (460°C, 860°F); HC (-9,420 Btu/lb, -5,230 cal/g,  $-219 \times 10^3$  J/kg); HF (-518.9 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS**: flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; dangerous fire hazard when exposed to heat, flame, or oxidizers; moderately explosive; flashback along vapor trail may occur; vapor may be explosive if ignited in confined area; can react vigorously with oxidizing materials; incompatible with nitrates, alkalies and acids; keep away from heat and open flame; use alcohol foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (narcotic effects, anesthetic effects, difficulty in breathing, irritates eyes and upper respiratory tract); contact (dermatitis); ingestion (no serious effects if swallowed).

**FIRST AID**: wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if ingested, drink water or milk.

**HUMAN TOXICITY DATA**: eye-human 200 ppm/15M; inhalation-human TCLo 200 ppm; toxic effect: irritant effects; unknown- human TCLo 200 ppm; toxic effect: eye.

**ACUTE HEALTH RISKS**: irritation of eyes, nose and skin; narcosis; anesthetic effects; irritation of respiratory tract.

**CHRONIC HEALTH RISKS**: liver damage; dermatitis; target organs: eyes, skin, respiratory system, central nervous system.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 250ppm; ACGIH TLV STEL 310 ppm; OSHA PEL TWA 250ppm ( $950\text{mg}/\text{m}^3$ ); OSHA PEL STEL 310 ppm; IDLH 1800 ppm.

**PERSONAL PROTECTION**: wear full protective clothing and self-contained breathing apparatus; chemical resistant gloves are recommended; wear chemical goggles or face splash shield.

**SPILL CLEAN-UP**: ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber equipped with effluent gas cleaning device; absorb as much as possible in noncombustible materials such as dry earth or sand; remove all sources of ignition

**DISPOSAL AND STORAGE METHODS**: absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; atomize large quantities in a suitable combustion chamber; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry, well-ventilated area; keep away from strong oxidizers, alkalies, nitrates, and acids.

**REGULATORY INFORMATION**: A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose derivatives, plastics, oils, fats, coatings, and printing inks, also used as a solvent for shellac, gums, and resins; useful as a synthetic flavoring ingredient and in the perfume industry.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 11; 12; 13; 14.

**KAOLIN (Al<sub>2</sub>Si<sub>2</sub>O<sub>5</sub>(OH)<sub>4</sub>, not applicable to mixtures)**

**CAS/DOT IDENTIFICATION #:** 1332-58-7/none

**SYNONYMS:** altowhite, china clay, clay, hydrate aluminum silicate, hydrite, kaolinite, kaopaous, porcelain clay.

**PHYSICAL PROPERTIES :** fine white to yellow-white powder; darkens and develops a clay-like odor when moistened; earth taste; possesses high lubricity (i.e., slipperiness); insoluble in water; not soluble in dilute acids, alcohol, ether, and alkali hydroxides; MP (unknown); BP (NA); DN (1.8-2.6 g/cm<sup>3</sup>); SG (1.8-2.6); VD (NA); VP (0 mmHg approximately); pH (4.5-6.5 (slurries)).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; no incompatibility data found; no hazardous decomposition products; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating Health 0, Flammability 0, Reactivity 0; not considered to be a fire hazard; not considered to be an explosion hazard; use any mean suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, chronic pulmonary fibrosis (lung scarring)); skin contact (no adverse effects expected); eye contact (no adverse effects expected but dust may cause mechanical irritation); ingestion (gastrointestinal disturbances caused by extremely large oral doses, stomach granuloma).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and get medical attention; in case of ingestion, no first aid measures are usually required.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** may cause irritation to respiratory tract; may produce gastrointestinal disturbances; dust may cause mechanical irritation to eyes.

**CHRONIC HEALTH RISKS:** chronic pulmonary fibrosis; stomach granuloma.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 mg(respiratory fraction)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear protective gloves and clean-body covering; use dust-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; wear positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; sweep up spills and containerize for reclamation or disposal; use vacuuming or wet sweeping to avoid dust dispersal.

**DISPOSAL AND STORAGE METHODS:** handle whatever cannot be saved for recovery or recycling in an approved waste facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; keep in tightly closed containers; protect against physical damage..

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a filler and coatings for paper and rubber, ceramics, cements, fertilizers, refractories, and chemicals (in particular, aluminum sulfate); used as an adsorbent for liquid clarification; other uses include anti-caking preparations, cosmetics, paint, electrical insulators, and a catalyst carrier; also, an excellent source of alumina.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### ISOPROPYLAMINE ((CH<sub>3</sub>)<sub>2</sub>CHNH<sub>2</sub>, 59.13)

**CAS/DOT IDENTIFICATION #:** 75-31-0/UN1221

**SYNONYMS:** 2-aminopropane, 1-methylethylamine, monoisopropylamine, 2-propanamine, 2-propylamine, sec-propylamine.

**PHYSICAL PROPERTIES :** colorless liquid; strong ammonia-like odor; miscible with water, alcohol and ether; soluble in benzene and chloroform; very soluble in acetone; exists as a gas above 91°F; MP (-101°C, -150°F); BP (34°C, 93°F); DN (0.694 g/mL at 15°C); LSG (0.69); ST (16.8 dynes/cm at 20°C); CP (163.8 J/K-mol liquid at 25°C); HV (193 Btu/lb, 107 cal/g, 4.48 x 10<sup>5</sup> J/kg); VD (2.04); VP (478 mmHg at 20°C); OT (0.504 mg/m<sup>3</sup> low odor, 480 mg/m<sup>3</sup> high odor).

**CHEMICAL PROPERTIES:** flammable liquid; strong base; high volatility; low flash point; relatively low ignition temperature; reacts with acids, aldehydes, ketones, epoxides, and oxidizing agents; FP (-37°C, -35°F); LFL/UFL (2.3%, 12%); AT (402°C, 756°F); HC (-9,420 cal/g, -16,940 Btu/lb, -394 x 10<sup>5</sup> J/kg); HF (-112.3 kJ/mol liquid at 25°C); H<sub>f</sub> (7.33 kJ/mol at 178K).

**EXPLOSION and FIRE CONCERNS:** flammable; flashback along vapor trail may occur; vapor may explode if ignited in a confined area; NFPA rating Health 3, Flammability 4, Reactivity 0; dangerous fire hazard and moderate explosion hazard; reacts vigorously with oxidizing materials; reacts with perchloryl fluoride to form an explosive liquid; incompatible with 1-chloro-1,3-epoxypropane; heating to decomposition emits toxic oxides of nitrogen; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, chest pain, lung edema, nose and throat irritation, convulsions, loss of consciousness); contact (severe eye and skin irritation, edema of the cornea, sensitization, dermatitis); ingestion (nausea, salivation, severe irritation of mouth and stomach).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if ingested, drink large quantities of water followed by dilute vinegar, lemon juice or other weak acid.

## 692 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**HUMAN TOXICITY DATA:** no data available in humans, but highly toxic via ingestion or inhalation; emits highly toxic vapors when burned.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; severe skin irritation; severe coughing; chest pain; pulmonary edema; loss of consciousness; visual disturbances; nausea; salivation; severe irritation of mouth and stomach; edema of the cornea; eye burns; narcotic effects in high concentrations.

**CHRONIC HEALTH RISKS:** local irritation of eyes or skin; skin sensitization; dermatitis; may cause allergic effects on direct contact with skin, eyes, and mucous membranes; target organs: eyes, skin, respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5ppm; ACGIH TLV STEL 10 ppm; OSHA PEL TWA 5ppm (12mg/m<sup>3</sup>); OSHA PEL STEL 10ppm; IDLH 750ppm.

**PERSONAL PROTECTION:** rubberized outerwear should be employed in areas of high concentration; wear butyl rubber gloves and apron; chemical face shield or safety goggles are also recommended; use self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spill to form non-flammable mixtures; absorb as much as possible in noncombustible materials such as dry earth or sand; flush remaining isopropylamine with large amounts of water but not into confined spaces such as sewers because of danger of an explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** atomize large amounts in a suitable combustion chamber equipped with effluent gas cleaning device; dissolve in flammable solvent and ignite in open pit or incinerator with afterburner and scrubber; add to layer of sodium bisulfate, spray with water, neutralize and route to sewage plant; store in a cool, dry location; separate from strong acids and oxidizing materials.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (3); labels (flammable liquid, corrosive).

**OTHER COMMENTS:** useful as a solvent; used as an intermediate in synthesis of rubber accelerators, pharmaceuticals, dyes, insecticides, bactericides, textile specialties, and surface-active agents; used in the manufacture of medicinals in purification of penicillin and streptomycin.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 10; 11; 12; 14.

### ISOPROPYL ETHER ((CH<sub>3</sub>)<sub>2</sub>CHOCH(CH<sub>3</sub>)<sub>2</sub>, 102.20)

**CAS/DOT IDENTIFICATION #:** 108-20-3/UN1159

**SYNONYMS:** diisopropyl ether, diisopropyl oxide, 2-isopropoxypropane, 2,2'-oxybispropane.

**PHYSICAL PROPERTIES :** clear, colorless liquid; sweet, ether-like odor; miscible with alcohol and ether; miscible with most organic solvents; soluble in acetone; slightly soluble in water; insoluble in dilute sulfuric acid; floats on water; MP (-60°C, -76°F); BP (69°C, 156°F); DN (0.719 g/mL at 25°C); LSG (0.82); ST (17.1 dynes/cm at 25°C); VS (0.273 cP at 20°C); CP (0.526 cal/g at 22-27°C); LHV (68.2 cal/g at 67.5°C); VD (3.52); VP (119.4 mmHg at 20°C); OT (8.0 x 10<sup>-4</sup> mg/L in water, 0.017 µL/L in air).

**CHEMICAL PROPERTIES:** flammable liquid; readily forms peroxides when exposed to oxygen unless stabilized with inhibitors such as hydroquinone; reacts with strong oxidizers and acids; FP (-28°C, -18°F); LFL/UFL (1.4%, 7.9%); AT (443°C, 830°F); HC (-16,900 Btu/lb, -9,390 cal/g, -393 x 10<sup>5</sup> J/kg); HF (-351.5 kJ/mol liquid at 25°C); H<sub>f</sub>(11.0 kJ/mol at 186.3K).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity N/A; flashback along vapor trail may occur; vapor may explode if ignited in a confined area; tends to form unstable peroxides on long contact with air; previously opened containers that remain in storage for more than six months are most likely to contain explosive peroxides; may accumulate static electricity; reacts violently with chlorosulfonic acid and nitric acids; dangerous reaction with propionyl chloride can burst a sealed container; vigorous reaction with oxidizing materials; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, headache, dizziness, anesthesia, irritation of the eyes and nose); contact (minor eye injury, removes natural skin oils, may cause dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; nausea; headache; dizziness; anesthesia.

**CHRONIC HEALTH RISKS:** systemic effects unknown; repeated contact with skin may cause dermatitis; target organs: eyes, skin, respiratory system, central nervous system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 250 ppm; ACGIH TLV STEL 310 ppm; OSHA PEL TWA 500 ppm (2100 mg/m<sup>3</sup>); NIOSH REL TWA 500 ppm (2100 mg/m<sup>3</sup>); IDLH 1400 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and self-contained breathing apparatus; wear chemical resistant gloves; splash-proof safety goggles are recommended.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** pour on ground in open air and cautiously ignite or allow to evaporate; dissolve in higher alcohol, benzene, or petroleum ether and atomize in a suitable combustion chamber; outside storage is preferred; inside storage should be in a standard flammable liquids storage room; avoid sunlight.

**REGULATORY INFORMATION:** CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for mineral oils, waxes, and resins; used to extract acetic acid from aqueous solutions; also is used as a solvent in the separation of polonium from lead and bismuth; a fuel additive.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 10; 11; 13; 14.

**ISOPROPYL GLYCIDYL ETHER (C<sub>6</sub>H<sub>12</sub>O<sub>2</sub>, 116.18)****CAS/DOT IDENTIFICATION #:** 4016-14-2/none

**SYNONYMS:** 1,2-epoxy-3-isopropoxypropane, 2,3-epoxypropyl isopropyl ether, glycidyl isopropyl ether, ige, (isopropoxymethyl) oxirane, isopropyl epoxypropyl ether, 3-isopropoxypropylene oxide.

**PHYSICAL PROPERTIES:** colorless liquid; ethereal odor; miscible with most organic solvents; MP (unknown); BP (137°C, 279°F); DN (0.9186 g/mL liquid at 20°C); LSG (0.92); VD (4.15); REL DN vapor/air mixture (1.04 at 20°C); VP (9 mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with oxidizing materials; reacts with acids; FP (33.3°C, 92.0°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; explosive vapor/air mixtures may be formed above 33°C; NFPA rating (not rated); may form explosive peroxides upon exposure to air or light; contact with strong oxidizers may cause fire and explosion; incompatible with strong caustics and acids; decomposes on contact with moist air and on burning, producing poisonous gases and vapors; use powder, foam, or carbon dioxide for firefighting purposes; hydrous agents and water may not be used.

**HEALTH SYMPTOMS:** inhalation (headache, drowsiness, unconsciousness, irritates eyes, skin and upper respiratory tract); contact (skin sensitization, dermatitis, redness); ingestion (weakness, fatigue, personality changes, decreased mental ability, possible blood effects, possible reproductive effects).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; rinse skin with plenty of water and soap; if breathing is difficult, provide oxygen; if breathing has stopped, administer artificial respiration; in case of ingestion, rinse mouth; give plenty of water to drink, then seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and throat; drowsiness; weakness; shaking; may cause effects on the central nervous system; could cause lowering of consciousness.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact may cause headache, drowsiness, weakness, fatigue, staggering, personality change, and decreased mental ability; exposure could cause encephalopathy (degenerative brain disease), bone marrow depression, and pancytopenia (reduced levels of all blood cells); may cause skin sensitization and dermatitis; lungs may be affected by inhalation of high concentrations of vapor; based on animal testing, has been reported to cause embryonic death, teratogenesis, or growth retardation; exposure to male animals has resulted in sterility and testicular atrophy.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (238 mg/m<sup>3</sup>); ACGIH TLV STEL 75 ppm (356 mg/m<sup>3</sup>); OSHA PEL TWA 50 ppm (240 mg/m<sup>3</sup>); NIOSH REL CL 50 ppm (240 mg/m<sup>3</sup>); IDLH 400 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; above 33°C, enclose operations and/or use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment; appropriate respirators are needed in areas where exposure

would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; collect spilled liquid in sealable containers or absorb with inert materials (e.g., dry earth, sand, or vermiculite); wash away remainder with plenty of water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be collected in sealable container or absorbed in sand or inert absorbent, and placed in a secured, sanitary landfill; store in a cool, dry location; maintain adequate ventilation; keep in the dark; store in tightly closed containers; fire-proof if in building; separate from strong oxidants.

**REGULATORY INFORMATION:** AI; CAL; DOT classification (none); labels (none).

**OTHER COMMENTS:** Isopropyl glycidyl ether can presumably form explosive peroxides upon exposure to air or light; consequently, the presence or absence of peroxides should be determined, especially prior to distillation; if present, they should be destroyed with sodium sulfite before distillation; may be used as a stabilizer of chlorinated solvents, and viscosity reducer of epoxy resins.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

### **KAOLIN (Al<sub>2</sub>Si<sub>2</sub>O<sub>5</sub>(OH)<sub>4</sub>, not applicable to mixtures)**

**CAS/DOT IDENTIFICATION #:** 1332-58-7/none

**SYNONYMS:** altowhite, china clay, clay, hydrate aluminum silicate, hydrite, kaolinite, kaopaous, porcelain clay.

**PHYSICAL PROPERTIES :** fine white to yellow-white powder; darkens and develops a clay-like odor when moistened; earth taste; possesses high lubricity (i.e., slipperiness); insoluble in water; not soluble in dilute acids, alcohol, ether, and alkali hydroxides; MP (unknown); BP (NA); DN (1.8-2.6 g/cm<sup>3</sup>); SG (1.8-2.6); VD (NA); VP (0 mmHg approximately); pH (4.5-6.5 (slurries)).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; no incompatibility data found; no hazardous decomposition products; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating Health 0, Flammability 0, Reactivity 0; not considered to be a fire hazard; not considered to be an explosion hazard; use any mean suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, chronic pulmonary fibrosis (lung scarring)); skin contact (no adverse effects expected); eye contact (no adverse effects expected but dust may cause mechanical irritation); ingestion (gastrointestinal disturbances caused by extremely large oral doses, stomach granuloma).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and get medical attention; in case of ingestion, no first aid measures are usually required.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** may cause irritation to respiratory tract; may produce gastrointestinal disturbances; dust may cause mechanical irritation to eyes.

**CHRONIC HEALTH RISKS:** chronic pulmonary fibrosis; stomach granuloma.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 mg(respirable fraction)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear protective gloves and clean-body covering; use dust-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; wear positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; sweep up spills and containerize for reclamation or disposal; use vacuuming or wet sweeping to avoid dust dispersal.

**DISPOSAL AND STORAGE METHODS:** handle whatever cannot be saved for recovery or recycling in an approved waste facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; keep in tightly closed containers; protect against physical damage..

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a filler and coatings for paper and rubber, ceramics, cements, fertilizers, refractories, and chemicals (in particular, aluminum sulfate); used as an adsorbent for liquid clarification; other uses include anti-caking preparations, cosmetics, paint, electrical insulators, and a catalyst carrier; also, an excellent source of alumina.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### **KETENE (C<sub>2</sub>H<sub>2</sub>O, 42.04)**

**CAS/DOT IDENTIFICATION #:** 463-51-4/none

**SYNONYMS:** carbomethene, ethenone, keto-ethylene.

**PHYSICAL PROPERTIES:** colorless gas; disagreeable taste and penetrating odor; soluble in water and alcohol; slightly soluble in ether; fairly soluble in acetone; M P (-150°C, -238°F); BP (-56°C, -69°F); DN/SG (NA); CP (51.8 J/K-mol gas at 25°C); HV (20.4 kJ/mol 223.34K); VD (1.45); VP (1.04 x 10<sup>4</sup> mmHg at 25°C); OT (no quantitative information available).

**CHEMICAL PROPERTIES:** may readily polymerize; reacts vigorously with water and a wide variety of organic compounds; decomposes in water; alcohol, and ammonia; FP (NA(gas)); LFL/UFL (data not available); AT (data not available); HC (1025.4 kJ/mol gas); HF (-67.9 kJ/mol liquid at 25°C, -47.5 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** extremely flammable gas; gas is heavier than air and may travel along the ground; distant ignition possible; forms explosive gas/air mixtures; substance may readily polymerize; reacts with water to form acetic acid; violent reaction with many organic compounds; NFPA rating (not rated); rapidly forms explosive diacetyl peroxide upon interaction with hydrogen peroxide; dimerizes to diketene even at low temperatures; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use dry powder or carbon

dioxide for firefighting purposes; avoid contact of the substance with water, since a violent reaction will result.

**HEALTH SYMPTOMS:** inhalation (irritates lungs, coughing, chest pain, shortness of breath, build-up of fluid in the lungs); contact (skin rash, irritates eyes, nose, mouth and throat).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; if breathing has stopped, administer respiratory support; transport promptly to a medical facility..

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, nose, and throat; irritation to respiratory system; coughing; chest pain; severe breathing difficulty; higher exposures can cause pulmonary edema and acute lung damage; capable of causing death due to exposures of normal use.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact may cause permanent lung damage, with fibrosis (lung scarring) and emphysema; prolonged skin contact can cause dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (0.86 mg/m<sup>3</sup>); ACGIH TLV STEL 1.5 ppm (2.6 mg/m<sup>3</sup>); OSHA PEL TWA 0.5 ppm (0.9 mg/m<sup>3</sup>); NIOSH REL TWA 0.5 ppm (0.9 mg/m<sup>3</sup>); NIOSH REL STEL 1.5 ppm (3 mg/m<sup>3</sup>); IDLH 5 ppm.

**PERSONAL PROTECTION:** wear gas-tight chemical protection suit including rubber gloves; wear gas-proof goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use explosion-proof electrical equipment and light; appropriate respirators are needed in areas where exposures are above the permissible exposure level; in high vapor concentrations, wear any self-contained breathing apparatus; all operations should be carried out in an efficient hood or enclosure.

**SPILL CLEAN-UP:** ventilate area of leak to disperse gas; stop flow of gas if possible; if source of leak is a cylinder, carefully remove leaking cylinder to a safe place in the open air, and allow cylinder to empty; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of by burning at a safe location or in a suitable combustion chamber; store in tightly closed containers in a cool, dry area; use only with adequate ventilation; protect containers against physical damage by shock; outside storage is preferred; for indoor storage, use standard flammable liquid storage room or cabinet; cannot be stored in gaseous state; avoid contact with water and a wide variety of organic compounds.

**REGULATORY INFORMATION:** A1; A5; CAL; cannot be shipped or stored in gaseous state.

**OTHER COMMENTS:** major use as a chemical intermediate in the preparation of dehydroacetic acid, acetoacetic esters, acetoacetanilide, n,n-dialkylacetoacetamides, and acetic anhydride from acetic acid; used as an acetylating agent in the manufacture of cellulose acetate and aspirin; starting point for making several commercial products, including acetate esters and acetic anhydride; utilized in the conversion of higher acids into their anhydrides.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 14; 15; 16.

**LEAD (Pb, 207.19)**

CAS/DOT IDENTIFICATION #: 7439-92-1/ none

SYNONYMS: lead flake, lead metal, pigment metal, plumbum.

**PHYSICAL PROPERTIES** : soft, bluish-gray metal; highly lustrous when freshly cut; very malleable; easily melted, cast, rolled, and extruded; tarnishes upon exposure to moist air; cubic crystal structure; poor conductor of electricity; good sound and vibration absorber; dissolve in dilute nitric acid; soluble in hot concentrated sulfuric acid, acetic acid, and alkali solutions; dissolves slowly in hydrogen chloride; insoluble in hot or cold water; MP (327.4°C, 621.3°F); BP (1740°C, 3164°F); DN (11.32 g/cm<sup>3</sup> at 20°C); SG (11.3); VS (3.2 cP at 327.4°C, 2.32 cP at 400°C, 1.54 cP at 600°C) (molten lead); CP (0.031 cal/g at 20°C); HV (206 cal/g at 1,740°C); VP (1.77 mmHg at 1000°C); BHN (4.0)(high purity lead); hardness 1 on Mohs scale.

**CHEMICAL PROPERTIES**: stable to oxygen and water at ordinary temperatures; attacked by pure water; attacked by weak, organic acids in presence of oxygen; resistant to tap water, hydrofluoric acid, brine, and solvent; reacts with hot concentrated nitric acid; reacts with boiling hydrochloric or sulfuric acid; TC (0.083 at 50°C-0.077 at 225°C); RS (20.65 μ-ohm-cm at 20°C); CLE (29 x 10<sup>-6</sup> at 0-100°C, 31.3 x 10<sup>-6</sup> at 20-300°C).

**EXPLOSION and FIRE CONCERNS**: flammable in dust form when exposed to heat or flame; NFPA rating Health 3, Flammability 2, Reactivity 0; moderately explosive in the form of dust when exposed to heat or flame; vigorous reaction with oxidizing materials; reacts violently on ignition with chlorine trifluoride, concentrated hydrogen peroxide, ammonium nitrate, and sodium acetylide; rubber gloves containing lead may ignite in nitric acid; explodes on contact with mixtures of hydrogen peroxide and trioxane; common air contaminant; incompatible with sodium azide, zirconium, disodium acetylide, and strong oxidants; decomposition emits highly toxic fumes of lead; use dry chemicals or sand with molten metals for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (weakness, insomnia, facial pallor); skin absorption (anorexia, vomiting, convulsions, malaise, permanent brain damage); ingestion (loss of appetite, gastric and liver changes).

**FIRST AID**: wash eyes immediately with large amounts of water; wash skin immediately with soap and water; for hot metal burns, cool exposed area with water; provide respiratory support.

**HUMAN TOXICITY DATA**: inhalation-human TCLo 10μg/m<sup>3</sup>; toxic effect: gastrointestinal tract, liver; cyt-human unreported 50μg/m<sup>3</sup>.

**ACUTE HEALTH RISKS**: anorexia; vomiting; convulsions due to increased intracranial pressure; malaise; insomnia; headache; loss of appetite; muscle and joint pains; tremors; hallucinations; central nervous system effects; gastrointestinal symptoms; brain damage; damage to kidneys; death.

**CHRONIC HEALTH RISKS**: weight loss; weakness; anemia; neurological symptoms; blood pressure effects; affects hearing threshold and growth in children; interference with vitamin D metabolism; severe depression of sperm counts; decrease function of the prostate; impaired mental development; decrease IQ scores in children; spontaneous abortion; low birth weight.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 0.15 mg/m<sup>3</sup>; OSHA PEL TWA 0.50 mg/m<sup>3</sup>; NIOSH REL TWA 0.10 mg/m<sup>3</sup>; IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and heat resistant gloves; wear chemical safety goggles; full-facepiece and self-contained breathing apparatus is recommended at a concentration of 100mg/m<sup>3</sup>; emergency showers and fire extinguishers are recommended around kilns.

**SPILL CLEAN-UP:** for water spill, neutralize with agricultural lime, crushed limestone, or sodium bicarbonate; adjust pH to neutral; remove immobilized masses of pollutants and precipitates; wet mopping, wet wiping, and wet vacuuming is recommended for dust control and for keeping dust levels down.

**DISPOSAL AND STORAGE METHODS:** add lime to precipitate basic lead carbonate and adsorb on activated carbon; route to metal salvage facility; store in sealed containers, plastic garbage cans with lids, or similar containers; separate from strong oxidizers, hydrogen peroxide, and acids.

**REGULATORY INFORMATION:** CA1; CA2; S1; S32-13; S51; S80; S82; R1; R2-9; R4; R6; R8; D waste #; (D008); Reportable Quantity (RQ): 10 lbs. (4.54 kg); Sf1; Sf3; CW5; A1; A4; CAL.

**OTHER COMMENTS:** used as construction material for tank lining, piping, and other equipment handling corrosive gases and liquid; used for x-ray and atomic radiation protection; used in the manufacture of tetraethyl lead and paint pigments; used in building construction.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13; 14; 19.

## **LIMESTONE (CaCO<sub>3</sub>, 100.1)**

**CAS/DOT IDENTIFICATION #:** 1317-65-3/none

**SYNONYMS:** calcium carbonate, natural calcium carbonate.

**PHYSICAL PROPERTIES :** white to tan powder; odorless, tasteless powder; soluble in dilute acids; practically insoluble in water and alcohol; solubility in water is increased by ammonium salt and by carbon dioxide; MP (825-1339°C, 1517-2442°F); BP (decomposes); DN (2.711-2.95 g/cm<sup>3</sup>); SG (2.7-2.95 at 20°C); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; contact with acids, aluminum, ammonium salts, or mercury and hydrogen causes a reaction; decomposes into calcium oxide and carbon dioxide at about 825°C (1517°F); may form at temperatures above and below 30°C (86°F); FP (NA); LFL/UFL (NA); AT(NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); a violent explosion occurs when a mixture with magnesium is heated in a current of hydrogen; contact with fluorine causes ignition; incompatible with acids, aluminum, and ammonium salts; toxic particulates (such as calcium oxide) may be released in a fire; in case of fire in the surroundings, use suitable extinguishing agent for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation to eyes, skin and respiratory system); contact (runny nose, sneezing, coughing, tearing of eyes, dry skin).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; administer cardiopulmonary resuscitation if breathing has stopped; in case of ingestion,

rinse mouth cavity several times with water; induce vomiting by giving syrup of ipecac, then seek medical attention.

**HUMAN TOXICITY DATA:** minimum lethal human exposure to this agent has not been reported; maximum tolerated human exposure to this agent has not been reported; chronic administration 4 to 60 g/day for 2 to 60 days combined with sodium bicarbonate have produced hypercalcemia, alkalosis, and renal dysfunction; no toxicity values for humans have been reported in the literature.

**ACUTE HEALTH RISKS:** irritation to eyes, skin, and mucous membranes; cough; sneezing; lacrimation (discharge of tears); rhinorrhea (discharge of thin nasal mucus).

**CHRONIC HEALTH RISKS:** no signs of symptoms of chronic exposure to calcium carbonate have been reported; similar exposure to impure limestone containing 3% to 20% quartz may pose a silicosis risk.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup> of inhalable dust (for particulate matter containing no asbestos and less than 1% crystalline silica); OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure limits; for extra personal protection, wear positive pressure self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; for small spills, vacuum or wet down spilled material; place into waste containers for proper disposal; for large spills, wet down the material and dike for proper disposal; avoid generating dust during cleanup; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; store in a cool, dry area; use only with adequate ventilation; storage should be in tightly sealed containers; containers should be protected from physical damage; separate from acids, aluminum, ammonium salts, fluorine, mercury, hydrogen, heat, sparks, and open flame.

**REGULATORY INFORMATION:** A1; DOT label (none).

**OTHER COMMENTS:** aragonite (MP: 825°C, DN: 2.83 g/cm<sup>3</sup>, formed at temperatures above 30°C) and calcite (MP: 1339°C at 102.5 atm, DN: 2.711 g/cm<sup>3</sup>, formed at temperatures below 30°C) are commercially important natural calcium carbonates; used in the manufacture of putty, tooth powders, whitewash, Portland cement, ceramics, polishes, foods, cosmetics, pharmaceuticals, antibiotics, antacids, adhesives, pencils, matches, linoleum, insulating compounds, etc.; used in removing sulfur dioxide from stack gases and as a neutralizing agent, filler, and extender in rubber, plastic, and paint products; utilized as a pigment and as a source of lime; useful in analytical chemistry in the detection and measurement of halogens in organic combinations.

**KEY REFERENCES:** 4; 5; 6; 15; 16.

**LINDANE (C<sub>6</sub>H<sub>6</sub>Cl<sub>6</sub>, 290.82)****CAS/DOT IDENTIFICATION #:** 58-89-9/2761**SYNONYMS:** gamma-benzene hexachloride, gamma-hexachlorane, gamma-hexachlorobenzene, gamma-isomer of 1,2,3,4,5,6-hexachlorocyclohexane.**PHYSICAL PROPERTIES:** white to yellow crystalline powder; slight musty odor; soluble in acetone, benzene, ether, and ethanol; insoluble in water; MP (112.5°C, 234.5°F); BP (323.4°C, 614°F at 760 mmHg); DN (1.85 g/mL); SG (1.85); VP (9.4 x 10<sup>-6</sup> mmHg at 20°C); OT (12 ppm).**CHEMICAL PROPERTIES:** stable to heat, light, and oxidation; corrosive to metals; very volatile in air; possesses more vapor activity than most organochlorine insecticides.**EXPLOSION and FIRE CONCERNS:** noncombustible solid, but may be dissolved in flammable liquids; NFPA rating 3; incompatible with strong oxidizing agents; hazardous decomposition products include carbon monoxide, carbon dioxide, and hydrogen chloride gas; decomposition emits toxic fumes of Cl<sub>2</sub>, hydrogen chloride, and phosgene; use water spray, dry chemical, carbon dioxide, or foam for firefighting purposes.**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin nose, and throat); skin absorption (hyperirritability, central nervous system excitation, vomiting, muscle spasms, convulsions); contact (dermatitis, urticaria).**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.**HUMAN TOXICITY DATA:** skin-man TDLo 20mg/kg/6W; toxic effect: eye, central nervous system; oral-child LDLo 180mg/kg; toxic effect: central nervous system, pulmonary; oral-child TDLo 111mg/kg; toxic effect: central nervous system.**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; dizziness; headache; nausea; vomiting; diarrhea; circulatory collapse; breathing difficulty; cyanosis; tremors; weakness; convulsions; anemia; elevated, itchy patches of skin; cardiovascular effects; effects on the gastrointestinal system; effects on the musculoskeletal system.**CHRONIC HEALTH RISKS:** effects on liver, blood, cardiovascular, and immune systems; local sensitivity reactions; EPA Group B2/C: possible human carcinogen..**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.5 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup>(skin); IDLH 50 mg/m<sup>3</sup>.**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear dust and splash-proof safety goggles; wear a filter mask and self-contained breathing apparatus.**SPILL CLEAN-UP:** evacuate area; approach release from upwind; use water spray to knock down vapor; carbon or peat may be used as sorbents; wastes may be treated by neutralization and settling.**DISPOSAL AND STORAGE METHODS:** dissolve in flammable solvent and atomize in a suitable combustion chamber equipped with scrubber and afterburner; mix with vermiculite, sodium carbonate, or sand-soda ash mixture in paper box, and cautiously ignite; store in a cool, dry place, separate from oxidizers and most metals; keep in tightly closed containers.

**REGULATORY INFORMATION:** CA2; S1; S24; S32-42; S50-b14; S61-c13; S62'-31; F2; F4; R1; R3; R4; D waste #; (D013); U waste # (U129); Reportable Quantity (RQ): 1 lb (0.454 kg); Sfl; Sfl2; Sfl3; CW1; CW2; A1; CAL.

**OTHER COMMENTS:** used as an insecticide for field crops, forestry, and livestock; used in soil and seed treatment; used in the treatment of head and body lice and scabies.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 12; 13; 14; 19.

### LITHIUM HYDRIDE (LiH, 7.95)

**CAS/DOT IDENTIFICATION #:** 7580-67-8/UN1414

**SYNONYMS:** lithium monohydride

**PHYSICAL PROPERTIES :** off-white to gray crystalline mass or white powder; translucent, moisture sensitive crystals; darkens rapidly on exposure to light; odorless; soluble in ether; insoluble in benzene and toluene; MP (680°C, 1256°F); BP (decomposes); DN (0.76-0.77 g/cm<sup>3</sup>); SG (0.78 at 20°C); CP (27.9 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible solid; thermally unstable; reacts with the lower alcohols, carboxylic acids, chlorine, and ammonia at 400°C to liberate hydrogen; reacts with water, forming hydrogen and lithium hydroxide; dissociates above melting point to form lithium metal and hydrogen; decomposes at 400°C (1009°F); FP (NA); LFL/UFL (NA); AT (NA); HF (-90.5 kJ/mol crystal at 25°C); H<sub>f</sub> (22.59 kJ/mol at 961.8K).

**EXPLOSION and FIRE CONCERNS:** flammable solid; dangerous fire risk; NFPA rating Health 3, Flammability 2, Reactivity 2; can form airborne dust clouds which may explode on contact with flame, heat, or oxidizers; ignites spontaneously in moist air; mixtures of the powder with liquid oxygen are explosive; evolves hydrogen and ignites on contact with water; ignites on contact with dinitrogen oxide and oxygen and moisture; may reignite after fire is extinguished; reacts violently with a broad range of materials, including strong oxidizers, halogenated hydrocarbons, acids, and water; combustion may produce irritants and toxic gases; use dry sand, dry clay, or dry ground limestone for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates lungs, respiratory tract, and mucous membranes); contact (nausea, muscular twitches, mental confusion, blurred vision); ingestion (mouth and esophagus burns).

**FIRST AID:** flush eyes immediately with plenty of water; if solid chemical contacts the skin, brush away excess (do not wash); provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** nausea; muscular twitches; mental confusion; blurred vision; severe eye and skin burns; burns of the mouth and esophagus (if ingested); irritation of lungs, respiratory tract, skin, and mucous membranes.

**CHRONIC HEALTH RISKS:** no chronic health risks reported in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.025 mg/m<sup>3</sup>; OSHA PEL TWA 0.025 mg/m<sup>3</sup>; NIOSH REL TWA 0.025 mg/m<sup>3</sup>; IDLH 0.5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear fire-retardant clothing; rubber or plastic gloves are recommended; wear chemical safety goggles and positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** shovel into suitable dry container; keep water away from release.

**DISPOSAL AND STORAGE METHODS:** shovel into suitable dry container and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; must be stored in a dry location; store under argon or nitrogen gas; keep away from strong oxidizers, acids, and halogenated hydrocarbons.

**REGULATORY INFORMATION:** Sf2; A1; CAL; DOT hazard class/division (4.3); labels (dangerous when wet).

**OTHER COMMENTS:** used as a condensing agent with ketones and acid esters; used in the preparation of lithium amide and double hydrides; also used as a reducing agent, a nuclear shielding material, a desiccant, and in hydrogen generators.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 11; 12; 14.

**L.P.G. (C<sub>3</sub>H<sub>8</sub>/ C<sub>3</sub>H<sub>6</sub>/C<sub>4</sub>H<sub>10</sub>/ C<sub>4</sub>H<sub>8</sub>, 42-58)**

**CAS/DOT IDENTIFICATION #:** 68476-85-7/UN1075

**SYNONYMS:** bottled gas, compressed petroleum gas, liquefied hydrocarbon gas, liquefied petroleum gas, LPG.

**PHYSICAL PROPERTIES:** colorless liquefied gas, a fuel mixture of propane, propylene, butanes and butylenes; mild hydrocarbon odor or odorless gas when pure; a foul-smelling odorant is usually added; negligible solubility in water; MP (> - 187°C, > - 305°F); BP (>-89°C, >128°F); DN/SG (0.5 – 0.6); VD (1.45 – 2.00); VP(> 1000 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react with strong oxidizing materials; incompatible with chlorine dioxide; non-corrosive; FP (< - 40°C, <40°F); LFL/UFL (2.1% (propane) 1.9% (butane), 9.5% (propane); 8.5% (butane)); AT (426 – 537°C, 799 – 998.6°F).

**EXPLOSION and FIRE CONCERNS:** extremely flammable gas; very dangerous fire hazard; NFPA rating (not rated); vapor accumulation could flash and/or explode if in contact with open flame; pressurized containers may explode if exposed to open flames and elevated temperatures; incompatible with strong oxidizers and chlorine dioxide; hazardous decomposition products include carbon monoxide and carbon dioxide; use carbon dioxide, dry chemical, foam or water fog for fire fighting purposes.

**HEALTH SYMPTOMS:** inhalation (lightheadedness, drowsiness, asphyxia, nausea, irritates respiratory system); skin contact (irritates skin, liquid causes frostbite).

**FIRST AID:** flush eyes thoroughly with large amounts of water for several minutes; flush affected areas of skin with plenty of water; if freeze burns occur, immerse affected area in warm water (between 100 – 110°F) for 30-60 minutes; if breathing is difficult, provide oxygen; begin rescue breathing if breathing has stopped; seek immediate medical assistance.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** can cause irritation or freeze burns if contact with liquid occurs; product is a simple asphyxiant, displacing oxygen in lungs, and as a result, diminishing its supply available to blood and tissues; continued lack of oxygen may result in convulsions and loss of consciousness; exposure may cause general central nervous system depression typical of anesthetic gases; other symptoms include irritation to respiratory system, lightheadedness, dizziness, nausea and drowsiness.

**CHRONIC HEALTH RISKS:** no information found in the literature.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm; OSHA PEL TWA 1000 ppm (1800 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (1800 mg/m<sup>3</sup>); IDLH 2000 ppm (based on 10% of lower explosive limit).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, thermally protective gloves, lab coat, leather apron or coveralls; wear approved chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; use non-sparking type tools and explosion proof electrical equipment; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in oxygen-deficient atmospheres; maintain eyewash fountains and safety showers in work area.

**SPILL CLEAN-UP:** stop flow of gas if possible; evaporate to atmosphere and use water spray to dilute vapor cloud; evacuate area; remove leaking containers to detached area; prevent spills from entering confined spaces such as storm sewers or drains; remove all sources of ignition..

**DISPOSAL AND STORAGE METHODS:** product is suitable for burning in an enclosed, controlled burner for fuel value or disposal by incineration; product may also be processed by an approved recycling facility; store in a cool area equipped with automatic sprinkling system; use in a well-ventilated area away from all ignition sources; outside storage is preferred; ground and bond storage containers to prevent sparking during transfers; keep away from heat, sparks and flame.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (2.1); label (flammable gas).

**OTHER COMMENTS:** used as a fuel refrigerant, propellant and raw material in chemical synthesis; other uses include automotive fuel, domestic and industrial fuel, welding, brazing and metal-cutting.

**KEY REFERENCES:** 4; 5; 6; 7; 14;

### **MAGNESITE (MgCO<sub>3</sub>, 84.32)**

**CAS/DOT IDENTIFICATION #:** 546-93-0/none

**SYNONYMS:** carbonate magnesium, carbonic acid, magnesium salt, hydromagnesite, magnesium carbonate, magnesium (II) carbonate.

**PHYSICAL PROPERTIES:** white, crystalline powder; very light-weight; odorless; insoluble in water; soluble in acids, alcohol, acetone, and ammonia; MP(350°C, 662°F) (decomposes); BP(decomposes); DN(3.04 g/cm<sup>3</sup>); SG(2.96 at 20°C); VD(not applicable); VP(approximately 0 mmHg at 20°C); MOHS HARDNESS (3.5-4.5).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; readily dissolves in aqueous acids forming the corresponding salts; decomposes on heating with liberation of carbon dioxide gas; decomposes at 350°C (662°F); FP(NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); reacts with acids liberating carbon dioxide, incompatible with formaldehyde; decomposes on heating producing irritating or toxic fumes; in case of fire in the surroundings, all extinguishing agents may be used for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory system); contact (cough, may have effects on lungs if containing >1% crystalline silica).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; rinse skin with plenty of water or shower; if breathing is difficult, provide oxygen; if breathing has stopped, provide respiratory support; in case of ingestion, seek medical advice.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; cough; particles of metallic magnesium or magnesium alloy that perforate the skin may produce a severe local lesion characterized by acute inflammatory reaction and evolution of gas.

**CHRONIC HEALTH RISKS:** substances may have effects on the lungs if the magnesite contains more than 1% crystalline silica.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 100 ppm (435 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (435 mg/m<sup>3</sup>); NIOSH REL STEL 150 ppm (655 mg/m<sup>3</sup>); IDLH 900 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; wear self-contained breathing apparatus in unknown concentrations or in IDLH conditions; for extra personal protection, use a P1 filter respirator for inert particles; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** sweep spilled substance into covered containers; if appropriate, moisten first to prevent dispersion of dust.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substances into sealable containers, and place in a secured, sanitary landfill; store in a cool, dry location; maintain adequate ventilation; separate from acids and formaldehyde.

**REGULATORY INFORMATION:** Al; DOT classification (none); labels (none).

**OTHER COMMENTS:** used in the manufacture of various grades of magnesium oxide, including caustic-calcined magnesia, dead-burned magnesia, and synthetic magnesite; used in the production of carbon dioxide gas; basic magnesite may be utilized as a refractory, its primary use being for the lining of steel furnaces, coke ovens, glass lehrs, and other continuous high-temperature applications.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

**MAGNESIUM OXIDE FUME (MgO, 40.31)**

CAS/DOT IDENTIFICATION #: 1309-48-4/none

**SYNONYMS:** calcined brucite, calcined magnesia, calcined magnesite, magnesia, magnesia fume.

**PHYSICAL PROPERTIES :** finely divided, white particulates dispersed in air; odorless; exposure may occur when magnesium is burned, thermally cut, or welded upon; very slightly soluble in pure water; solubility increased by carbon dioxide; soluble in dilute acids and ammonium salt solutions; not soluble in alcohol; highly reflective in visible region and near ultra-violet region; MP (2800°C, 5072°F); BP (3600°C, 6512°F); DN (3.65-3.75 g/cm<sup>3</sup> solid); SG (3.58 at 25°C); CP (37.2 J/K-mol crystal at 25°C); VD (no information found); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; absorbs carbon dioxide and water from air; reacts with halogens and strong acids; FP (NA); LFL/UFL (NA); AT (NA); HF (-601.6 kJ/mol crystal at 25°C); H<sub>f</sub> (78 kJ/mol at 3099K).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; not considered to be a fire hazard; NFPA rating Health 1, Flammability 0, Reactivity 0; reacts violently with halogens and strong acids; violent reaction or ignites on contact with interhalogens such as chlorine trifluoride (ClF<sub>3</sub>) or bromine pentafluoride (BrF<sub>5</sub>); reacts incandescently with phosphorus pentachloride (PCl<sub>5</sub>); no known hazardous decomposition ion products; in case of fire in the surroundings, all extinguishing agents may be used for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, chills, fever, headache, aching muscles, chest pain, dry mouth and throat); skin contact (no adverse effects expected); eye contact (may cause irritation); ingestion (nausea, diarrhea).

**FIRST AID:** wash eyes thoroughly with running water; promptly wash affected areas of skin with plenty of soap and water; remove to fresh air if inhaled; get immediate medical attention for any breathing difficulty; in case of ingestion, dilute by drinking several glasses of water; get medical advice if large amounts were swallowed.

**HUMAN TOXICITY DATA:** inhalation-human TCl<sub>0</sub> 400 mg/m<sup>3</sup>; investigated as a tumorigen.

**ACUTE HEALTH RISKS:** may cause irritation to nasal passages; irritation to respiratory tract; flu-like illness (metal fume fever) may be caused by exposure to freshly formed fumes; symptoms of metal fume fever include headache, cough, sweating, chills, fever, aching muscles, nausea, and dryness in mouth and throat; may cause rapid bowel evacuation.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (10 mg/m<sup>3</sup>)(as fume); OSHA PEL TWA 15 mg/m<sup>3</sup>(as fume); DFG MAK 6 ppm (6 mg/m<sup>3</sup>)(as fume); IDLH 750 mg/m<sup>3</sup> (as fume).

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; use chemical safety goggles in combination with breathing protection; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing protection apparatus; for extra personal protection, wear P1 filter respirator for inert particles; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; sweep spilled substance into containers; use vacuuming or wet sweeping to avoid dust dispersal; wash away remaining spill with large amounts of water.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in accordance with federal, state and local requirements; store in a cool, dry area; use only with adequate ventilation; keep in a tightly closed container; protect against physical damage; separate from strong acids and halogens.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** magnesium oxide may be used in the manufacture of refractories, particularly for linings of steel furnaces; use as a reflector in optical instruments, in the removal of sulfur dioxide from stack gases, and in adsorption and catalysis; other uses include pharmaceuticals, cosmetics, electrical insulation, and paper manufacture.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **MALATHION (C<sub>10</sub>H<sub>19</sub>O<sub>6</sub>PS<sub>2</sub>, 330.38)**

**CAS/DOT IDENTIFICATION #:** 121-75-5/UN3082

**SYNONYMS:** s-[1,2-bis(ethoxycarbonyl)ethyl]-o,o-dimethylphosphorodithioate, diethyl (dimethoxyphosphinothiolythio)succinate, o,o-dimethyl-s-(1,2-dicarbethoxyethyl)thiothionophosphate, malatol<sup>®</sup>, malatox<sup>®</sup>, sumitox<sup>®</sup>, zithiol<sup>®</sup>.

**PHYSICAL PROPERTIES:** clear yellow to deep brown liquid; a solid below 37°F; garlic-like odor; slightly soluble in water; miscible with most organic solvents including alcohols, ketones, ethers, esters, aromatic and alkylated aromatic hydrocarbons, and vegetable oils; solubility is limited in certain alkane hydrocarbons; petroleum ether is soluble to about 35% in malathion; MP (3.0°C, 37.4°F); BP (156-157°C, 313-315°F at 0.7 mmHg); DN (1.23 g/mL liquid at 25°C); LSG (1.21 at 20°C); VD (11.4); REL DN vapor/air mixture (1.00 at 20°C); VP (4 x 10<sup>-5</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; stable in an aqueous solution buffered to pH 5.26; undergoes hydrolysis at pH greater than 7.0 or less than 5.0; corrosive to metals; reacts vigorously with strong oxidizers; FP (>163°C, >325°F); LFL/UFL (unknown); AT (unknown); HC (data not found in literature).

**EXPLOSION and FIRE CONCERNS:** combustible liquid, but may be difficult to ignite; liquid formulations containing organic solvents may be flammable and explosive; violent reaction with strong oxidants; attacks iron and some other metals, some plastics and rubber; incompatible with magnesium and alkaline pesticides; decomposes on heating or on burning producing toxic fumes of phosphorus oxides and oxides of sulfur; use powder, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, pupillary constriction, muscle cramps, excessive salivation, sweating, labored breathing, chest tightness, unconsciousness); skin absorption (giddiness, confusion, respiratory failure, convulsions); ingestion (blood pressure depression, difficulty in breathing, abdominal cramps, nausea, vomiting, diarrhea).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult,

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provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, rinse mouth and seek immediate medical attention.

**HUMAN TOXICITY DATA:** oral-man LDLo 471 mg/kg; toxic effect: central nervous system, cardiovascular system, pulmonary effects; oral-woman LDLo 246 mg/kg; sister chromatid exchange-human lymphocyte 40 mg/L.

**ACUTE HEALTH RISKS:** headache; dizziness; aching eyes; blurred vision; lacrimation; irritation to eyes and skin; pupillary constriction; excessive salivation; muscle cramp; sweating; labored breathing; rhinorrhea; wheezing; laryngeal spasms; tightening of chest; abdominal cramps; nausea; vomiting; diarrhea; miosis; giddiness; confusion; ataxia; may cause effects on nervous system, resulting in convulsions and respiratory failure; loss of consciousness; exposure to high concentrations may result in death.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact may cause allergic sensitization of skin; an organic phosphate cholinesterase inhibitor; cumulative effect of acute hazards/symptoms is possible; may possibly cause reproductive effects in humans; human mutation data has been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup> (skin); OSHA PEL TWA 15 mg/m<sup>3</sup> (skin); NIOSH REL TWA 10 mg/m<sup>3</sup> (skin); IDLH 250 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab-coat, apron or coveralls; use splash-proof safety goggles; a closed system of local exhaust ventilation is recommended at the site of chemical release; appropriate respirators are needed in areas where exposures are above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area; for extra personal protection, use a P2 filter respirator for organic vapor and harmful dust.

**SPILL CLEAN-UP:** ventilate area of spill or leak; collect spilled material in sealed containers or absorb with noncombustible materials (e.g., dry earth, sand or vermiculite); flush remaining liquid with large amounts of water but not into confined spaces such as sewers because of possibility of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry area; use only with adequate ventilation; separate from strong oxidants, some metals, food and feedstuffs; avoid open flames.

**REGULATORY INFORMATION:** F2; F5; F7; F8; Reportable Quantity (RQ): 100 lbs (45.4 kg); Sfl; S3; CW1; CW2; A1; CAL; DOT hazard class/division (9); label (do not transport with food and feedstuffs).

**OTHER COMMENTS:** an insecticide that has been used with effectiveness on the Mediterranean fruit fly; this substance is very toxic to aquatic organisms and may be hazardous to the environment.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14.

### **MALEIC ANHYDRIDE(C<sub>4</sub>H<sub>2</sub>O<sub>3</sub>, 98.06)**

**CAS/DOT IDENTIFICATION #:** 108-31-6/UN2215

**SYNONYMS:** cis-butenedioic anhydride; 2,5-furanedione, maleic acid anhydride, toxilic anhydride.

**PHYSICAL PROPERTIES** : colorless or white solid; forms orthorhombic crystals; irritating, choking odor; soluble in dioxane, ether, acetate, and chloroform; soluble in alcohol with ester formation; soluble in water; forming maleic acids; slightly soluble in ligroin; MP (53°C, 127°F); BP (202°C, 395°F); DN (1.48 g/cm<sup>3</sup> at 20°C); SG (1.48); SH (0.285 (solids), 0.396 (liquids)); VD (3.4); VP (0.16 mmHg at 20°C); OT (1.84 mg/m (low), 1.96 mg/m (high)).

**CHEMICAL PROPERTIES**: stable under normal laboratory conditions; corrosive; reacts with strong oxidizers, alkalis, metals, caustics, and amines above 150°F; hydrolyzes slowly to form maleic acid; FP (102°C, 215°F); LFL/UFL (1.4%, 7.1%); AT (477°C, 890°F); HC (-5,936 Btu/lb, -3,298 cal/g, -138 x 10<sup>5</sup> J/kg).

**EXPLOSION and FIRE CONCERNS**: combustible solid; dust cloud may explode upon exposure to flame or spark; NFPA rating Health 3, Flammability 1, Reactivity 1; reacts vigorously with oxidizing materials; reacts violently with sodium hydroxide, potassium hydroxide, and calcium hydroxide; explosive reaction with sodium, potassium, dimethylamine, triethylamine, lithium, and pyridine; incompatible with cations; reaction with water or steam releases energy; vapor form explodes when exposed to heat or flame; may generate electrostatic charges; decomposition emits toxic vapors; use water spray, dry chemical, carbon dioxide, or foam for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (coughing, sneezing, throat irritation); skin absorption (severe eye irritation, photophobia, double vision); contact (severe skin irritation and redness).

**FIRST AID**: wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA**: no toxicity data available in humans.

**ACUTE HEALTH RISKS**: irritation of eyes, nose and throat; irritation of the upper respiratory tract; burning in the larynx; reflex cough; lacrimation; headaches; nosebleeds; impairment of vision; double vision; allergic reactions.

**CHRONIC HEALTH RISKS**: bronchial asthma; chronic bronchitis; pulmonary edema; dermatitis.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 0.25 ppm; OSHA PEL TWA 0.25 ppm (1mg/m<sup>3</sup>) NIOSH REL TWA 0.25 ppm (1 mg/m<sup>3</sup>) IDLH 10mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear coveralls, rubber apron, rubber gloves and boots; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP**: ventilate area; sweep small quantities onto paper or other suitable material; place in a tightly sealed container, and cautiously ignite in a safe area; dissolve in a flammable solvent and atomize in a suitable combustion chamber.

**DISPOSAL AND STORAGE METHODS**: dilute with large amounts of water and route to a sewage plant; mix with flammable solvent and spray into incinerator equipped with afterburner and scrubber; package solid acid in paper and burn in incinerator; store in a cool, dry place; outside storage preferred; isolate from oxidizing materials, alkalies, alkali metals, and amines.

**REGULATORY INFORMATION**: CA2; R4; R6; U waste #; (U147); Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sf1; Sf3; CW1; CW2; T120-a; A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used as a dienophile in Diels-Alder synthesis; used in the manufacture of dye intermediates, pharmaceuticals, and agricultural chemicals, used in the formation of fumaric and tartaric acid; used in copolymerization reactions.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 19.

### **MANGANESE COMPOUNDS (Mn, 54.94)**

**CAS/DOT IDENTIFICATION #:** 7439-96-5/NA

**SYNONYMS:** colloidal manganese, mangacat, manganese-55.

**PHYSICAL PROPERTIES :** steel gray metal; lustrous, hard, brittle metal; exists in four allotropic forms:  $\alpha$ -form (body-centered cubic),  $\beta$ -form (cubic),  $\gamma$ -form (face-centered cubic) and  $\delta$ -form (body-centered cubic); solids do not evaporate; small dust particles can become suspended in air; MP(1244°C, 2271°F); BP(2060°C, 3740°F); DN(7.20 g/cm<sup>3</sup> at 20°C); SG(7.20); CP(0.115 cal/g°C); VP(1 mmHg at 1292°C); Mohs' hardness 5.0.

**CHEMICAL PROPERTIES:** superficially oxidized on exposure to air; burns with an intense white light when heated in air; reacts with water or steam to produce hydrogen; reacts with aqueous solutions of sodium or potassium bicarbonate reacts with diluted mineral acids with formation of divalent manganous salts and evolution of hydrogen; powder form reduces most metallic oxides on heating; reacts directly with carbon, phosphorous, antimony, or arsenic on heating; LH<sub>f</sub> (3.5 kcal/g-atom).

**EXPLOSION and FIRE CONCERNS:** flammable and moderately explosive in the form of dust or powder on exposure to heat or flame; NFPA rating (not available); dust may explode when heated in carbon dioxide; powdered metal ignites on contact with fluorine, chlorine + heat, sulfur dioxide + heat, hydrogen peroxide, and bromine pentafluoride; reacts violently with nitrogen dioxide and oxidants; incandescent reaction with phosphorous, nitric acid, and nitryl fluoride; reaction with water or steam produces hydrogen; mixtures of aluminum dust and manganese dust may explode in air; mixtures with ammonium nitrate may explode on heating; use special dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, vomiting, nausea, abdominal pain); skin absorption (pulmonary damage, central nervous system damage); contact (eye irritation, skin irritation, vesiculation).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man TCl<sub>o</sub> 2300 µg/m<sup>3</sup>; toxic effect: brain, central nervous system.

**ACUTE HEALTH RISKS:** no information is available on the acute effects in humans; development of symptoms usually take from 1 to 3 years.

**CHRONIC HEALTH RISKS:** Parkinsonism; multiple sclerosis; amyotrophic lateral sclerosis; mental confusion; central nervous system effects; speech disturbances; tremors; psychological disturbances; speak with slow monotonous voice; muscular twitching; nocturnal cramps of legs; increased incidence of cough; bronchitis; increased susceptibility to lung disease; increased risk of pneumonia; sleepiness; impotence and loss of libido in men; increased risk of sterility; mask-like face; weakness; lethargy; metal fume fever: dry throat, coughing, tight chest, breathing difficulty, flu-like fever; lower back pain; vomiting; malaise; fatigue; kidney damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (dust and compounds) 5 mg/m<sup>3</sup>; ACGIH TLV STEL (fume) 3 mg/m<sup>3</sup>; ACGIH TLV (fume) 1 mg/m<sup>3</sup>; OSHA PEL TWA (fume) 1 mg/m<sup>3</sup>; OSHA PEL STEL (fume) 3 mg/m<sup>3</sup>; OSHA PEL (dust and compounds) 5 mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; NIOSH REL STEL 3 mg/m<sup>3</sup>; IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use dust explosion-proof electrical equipment and lighting; for extra personal protection, use a P2 filter respirator for harmful particles; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep spilled substance into containers; collect remaining material, then remove to a safe place; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substance into containers and dispose of in a secured, sanitary landfill; store in a cool, dry location; use only with adequate ventilation; separate from acids..

**REGULATORY INFORMATION:** CA2; A1.

**OTHER COMMENTS:** use as a constituent for several alloys, including ferromanganese and copper manganese; use in the production of steel; used for rock crushers and railway points and crossings

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 19.

## **MANGANESE FUME (Mn, 54.94)**

**CAS/DOT IDENTIFICATION #:** 7439-96-5/NA

**SYNONYMS:** colloidal manganese, mangacat manganese-55.

**PHYSICAL PROPERTIES :** steel gray metal; lustrous, hard, brittle metal; exists in four allotropic forms:  $\alpha$ -form (body-centered cubic),  $\beta$ -form (cubic),  $\gamma$ -form (face-centered cubic), and  $\delta$ -form (body-centered cubic); solids do not evaporate; small dust particles can become suspended in air; MP(1244°C, 2271°F); BP(2060°C, 3740°F); DN(7.20 g/cm<sup>3</sup> at 20°C); SG(7.20); CP(0.115 cal/g°C); VP(1 mmHg at 1292°C); Mohs' hardness 5.0.

**CHEMICAL PROPERTIES:** superficially oxidized on exposure to air; burns with an intense white light when heated in air; reacts with water or steam to produce hydrogen; reacts with aqueous solutions of sodium or potassium bicarbonate reacts with diluted mineral acids with formation of divalent manganous salts and evolution of hydrogen; powder form reduces most metallic oxides on heating; reacts directly with carbon, phosphorous, antimony, or arsenic on heating; LH<sub>f</sub> (3.5 kcal/g-atom).

**EXPLOSION and FIRE CONCERNS:** flammable and moderately explosive in the form of dust or powder on exposure to heat or flame; NFPA rating (not available); dust may explode when heated in carbon dioxide; powdered metal ignites on contact with fluorine, chlorine + heat, sulfur dioxide + heat, hydrogen peroxide, and bromine pentafluoride; reacts violently with nitrogen dioxide and oxidants; incandescent reaction with phosphorous, nitric acid, and nitril fluoride; reaction with water or steam produces hydrogen; mixtures of aluminum dust and manganese dust may explode in air; mixtures with ammonium nitrate may explode on heating; use special dry chemical for firefighting purposes.

## 712 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**HEALTH SYMPTOMS:** inhalation (headache, vomiting, nausea, abdominal pain); skin absorption (pulmonary damage, central nervous system damage); contact (eye irritation, skin irritation, vesiculation).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes flush skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man TCLo 2300  $\mu\text{g}/\text{m}^3$ ; toxic effect: brain central nervous system.

**ACUTE HEALTH RISKS:** no information is available on the acute effects in humans development of symptoms usually take from 1 to 3 years.

**CHRONIC HEALTH RISKS:** parkinsonism; multiple sclerosis; amyotrophic lateral sclerosis; mental confusion; central nervous system effects; speech disturbances; tremors; psychological disturbances; speak with slow monotonous voice; muscular twitching; nocturnal cramps of legs; increased incidence of cough; bronchitis; increased susceptibility to lung disease increased risk of pneumonia; sleepiness; impotence and loss of libido in men; increased risk of sterility; mask-like face; weakness; lethargy; metal fume fever: dry throat, coughing, tight chest breathing difficulty, flu-like fever; lower back pain; vomiting; malaise; fatigue; kidney damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (dust and compounds) 5  $\text{mg}/\text{m}^3$ ; ACGIH TLV STEL (fume) 3  $\text{mg}/\text{m}^3$ ; ACGIH TLV (fume) 1  $\text{mg}/\text{m}^3$ ; OSHA PEL TWA (fume) 1  $\text{mg}/\text{m}^3$ ; OSHA PEL STEL (fume) 3  $\text{mg}/\text{m}^3$ ; OSHA PEL (dust and compounds) 5  $\text{mg}/\text{m}^3$ ; NIOSH REL TWA 1  $\text{mg}/\text{m}^3$ ; NIOSH REL STEL 3  $\text{mg}/\text{m}^3$ ; IDLH 500  $\text{mg}/\text{m}^3$ .

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use dust explosion-proof electrical equipment and lighting; for extra personal protection, use a P2 filter respirator for harmful particles; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep spilled substance into containers; collect remaining material, then remove to a safe place; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substance into containers and dispose of in a secured, sanitary landfill; store in a cool, dry location; use only with adequate ventilation; separate from acids.

**REGULATORY INFORMATION:** CA2; A1.

**OTHER COMMENTS:** use as a constituent for several alloys, including ferromanganese and copper manganese; use in the production of steel; used for rock crushers and railway points and crossings

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 19.

### MARBLE ( $\text{CaCO}_3$ , 100.1)

**CAS/DOT IDENTIFICATION #:** 1317-65-3/none

**SYNONYMS:** calcium carbonate, natural calcium carbonate.

**PHYSICAL PROPERTIES** : white powder; odorless, tasteless powder; soluble in dilute acids; practically insoluble in water and alcohol, solubility in water is increased by ammonium salt and by carbon dioxide; MP (825-1339°C, 1517-2442°F); BP (decomposes); DN (2.711-2.95 g/cm<sup>3</sup>); SG (2.7-2.95 at 20°C); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES**: stable under ordinary conditions of use and storage; hazardous polymerization will not occur; contact with acids, aluminum, ammonium salts, or mercury and hydrogen causes a reaction; decomposes into calcium oxide and carbon dioxide at about 825°C (1517°F); may form at temperatures above and below 30°C (86°F); FP (NA); LFL/UFL (NA); AT(NA); HC (NA).

**EXPLOSION and FIRE CONCERNS**: noncombustible solid; NFPA rating (not rated); a violent explosion occurs when a mixture with magnesium is heated in a current of hydrogen; contact with fluorine causes ignition; incompatible with acids, aluminum, and ammonium salts; toxic particulates (such as calcium oxide) may be released in a fire; in case of fire in the surroundings, use suitable extinguishing agent for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (irritation to eyes, skin and respiratory system); contact (runny nose, sneezing, coughing, tearing of eyes, dry skin).

**FIRST AID**: immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; administer cardiopulmonary resuscitation if breathing has stopped; in case of ingestion, rinse mouth cavity several times with water; induce vomiting by giving syrup of ipecac, then seek medical attention.

**HUMAN TOXICITY DATA**: minimum lethal human exposure to this agent has not been reported; maximum tolerated human exposure to this agent has not been reported; chronic administration 4 to 60 g/day for 2 to 60 days combined with sodium bicarbonate have produced hypercalcemia, alkalosis, and renal dysfunction; no toxicity values for humans have been reported in the literature.

**ACUTE HEALTH RISKS**: irritation to eyes, skin, and mucous membranes; cough; sneezing; lacrimation (discharge of tears); rhinorrhea (discharge of thin nasal mucus).

**CHRONIC HEALTH RISKS**: no signs of symptoms of chronic exposure to calcium carbonate have been reported; similar exposure to impure limestone containing 3% to 20% quartz may pose a silicosis risk.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 10 mg/m<sup>3</sup> of inhalable dust (for particulate matter containing no asbestos and less than 1% crystalline silica); OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION**: wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure limits; for extra personal protection, wear positive pressure self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP**: ventilate area of spill; for small spills, vacuum or wet down spilled material; place into waste containers for proper disposal; for large spills, wet down the material and dike for proper disposal; avoid generating dust during cleanup; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state and local regulations; store in a cool, dry area; use only with adequate ventilation; storage should be in tightly sealed containers; containers should be protected from physical damage; separate from acids, aluminum, ammonium salts, fluorine, mercury, hydrogen, heat, sparks, and open flame.

**REGULATORY INFORMATION:** A1; DOT label (none).

**OTHER COMMENTS:** marble is a metamorphic form of calcium carbonate; used in the manufacture of putty, tooth powders, whitewash, Portland cement, ceramics, polishes, foods, cosmetics, pharmaceuticals, antibiotics, antacids, adhesives, pencils, matches, linoleum, insulating compounds, etc.; used in removing sulfur dioxide from stack gases and as a neutralizing agent, filler, and extender in rubber, plastic, and paint products; utilized as a pigment and as a source of lime; useful in analytical chemistry in the detection and measurement of halogens in organic combinations.

**KEY REFERENCES:** 4; 5; 6; 15; 16.

## MERCURY, ARYL AND INORGANIC COMPOUNDS (Hg, 200.6)

**CAS/DOT IDENTIFICATION #:** 7439-97-6/UN2809

**SYNONYMS:** synonyms may vary depending upon specific compound.

**PHYSICAL PROPERTIES :** most inorganic mercury compounds are white powders or crystals; mercuric sulfide (cinnabar) is red and turns black when exposed to light; insoluble in hydrochloric or similar acids; soluble in nitric acid and hot concentrated sulfuric acid; water soluble salts include mercuric chlorate, cyanide, chloride and acetate; oxides, sulfates and most other common salts, including mercurous chloride, are sparingly soluble or decomposed in water; appearances vary from colorless crystals to yellow, red (oxide, sulfide, iodide), and brown or black (sulfide); MP (-39°C, -38°F); BP (357°C, 674°F); DN (13.534 g/cm<sup>3</sup> at 25°C); SG (13.5); VD (not applicable); VP (0.0012 mmHg at 20°C).

**CHEMICAL PROPERTIES:** mercury salts yield metallic mercury when heated with sodium carbonate; mercury salts may be reduced to metal by hydrogen peroxide in presence of alkali hydroxide; soluble ionized mercuric salts give a yellow precipitate or mercuric oxide with sodium hydroxide and a red precipitate of mercury diiodide with alkali iodide; mercurous salts give a black precipitate with alkali hydroxides and a white precipitate of mercurous chloride (calomel) with hydrogen chloride or soluble chlorides; decomposes slowly on exposure to sunlight.

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating (not rated); mercurous chloride is incompatible with bromides, iodides, alkali chlorides, sulfates, sulfites, carbonates, hydroxides, ammonia, silver salts, copper salts, hydrogen peroxide, iodine, and iodoform; mercuric oxide reacts explosively with acetyl nitrate, chlorine and hydrocarbons, butadiene and ethanol and iodine (at 35°C), and hydrogen peroxide and traces of nitric acid; forms heat or shock-sensitive explosive mixtures with metals and non-metals; contact with acetylene, acetylene products, or ammonia gases may form solid products that are sensitive to shock and which can initiate fires of combustible materials; decomposition emits highly toxic fumes of Hg; use water spray, fog, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (central nervous system damage, kidney damage, weight loss).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man TDLo 44,300  $\mu\text{g}/\text{m}^3/8\text{H}$ ; toxic effect: central nervous system, liver, MET; inhalation-woman TCLo 150 $\mu\text{g}/\text{m}^3/46\text{D}$ ; toxic effect: central nervous system, gastrointestinal tract; skin-man TDLo 129 $\text{mg}/\text{kg}/5\text{H}$ ; toxic effect: ear, central nervous system, skin.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and mucous membranes; severe nausea; vomiting; abdominal pain; renal damage; prostration; chest pain; dyspnea; bronchitis; pneumonitis; insomnia; headache; fatigue; weakness; irritability; gastrointestinal disturbances; anorexia; low weight; proteinuria.

**CHRONIC HEALTH RISKS:** tremors; trouble remembering and concentrating; increased salivation; gum problems; loss of appetite and weight; changes in mood and personality; hallucinations; psychosis; clouding of the eyes; skin allergies; grayish skin color; kidney damage; decreased sex drive.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 $\text{mg}(\text{Hg})/\text{m}^3$  (skin); OSHA PEL CL 0.1  $\text{mg}(\text{Hg})/\text{m}^3$  (skin); NIOSH REL CL 0.1  $\text{mg}/\text{m}^3$  (skin); IDLH 10 $\text{mg}(\text{Hg})/\text{m}^3$ .

**PERSONAL PROTECTION:** wear full protective clothing (suits, gloves, footwear, headgear, etc.); wear chemical safety goggles and face shield; full facepiece respiratory protection is recommended; eye wash fountains should be provided in the immediate work area..

**SPILL CLEAN-UP:** ventilate area of spill; use a specialized charcoal-filtered vacuum or suction pump to collect all visible material; sprinkle the entire area of the spill with elemental zinc powder; use a 5-10% sulfuric acid solution to dampen the zinc powder to create a paste-like consistency; after paste dries to a light gray color, it may be swept up and disposed of properly; residual material is removed with soap and water.

**DISPOSAL AND STORAGE METHODS:** contain and dispose of mercury as a hazardous waste; contact your Department of Environmental Protection (DEP) or you regional office of the federal Environmental Protection Agency (EPA) for specific recommendations; store in tightly closed containers in a cool, well-ventilated area; keep away from acetylene, ammonia and nickel; store in secure poison area..

**REGULATORY INFORMATION :** A1; DOT hazard class/ division (6.1); labels (poison).

**OTHER COMMENTS:** inorganic salts of mercury, such as ammoniated mercuric chloride or mercuric iodide have been used in skin lightening creams; mercuric chloride has been used as a topical antiseptic or disinfectant agent; mercuric sulfide and mercuric oxide are used as pigments in paints; mercuric sulfide is also used as a pigment for tattoos; some inorganic mercury compounds are also used in fungicides.

**KEY REFERENCES:** 3; 4; 5; 6; 15; 16; 18; 19.

**MERCURY (ORGANO) ALKYL COMPOUNDS (as Hg)** ((Organo) alkyl mercury compounds have variable molecular formulas and variable formula weights, Physical and chemical properties of the following specific compounds are provided: dimethylmercury ( $\text{C}_2\text{H}_6\text{Hg}$ ), diethylmercury ( $\text{C}_4\text{H}_{10}\text{Hg}$ ) and ethyl mercuric chloride ( $\text{C}_2\text{H}_5\text{HgCl}$ ), having formula weights of 230.7, 258.7, and 265.1, respectively).

**CAS/DOT IDENTIFICATION #:** 7439-97-6/none

**SYNONYMS:** Synonyms vary depending upon the specific (organo) alkyl mercury compound; (dimethylmercury) mercury dimethyl; (diethylmercury) mercury diethyl; (ethylmercuric chloride); chloroethylmercury, cersan.

**PHYSICAL PROPERTIES:** Appearance, odor, and other physical properties vary depending upon the specific (organo) alkyl mercury compound. (dimethylmercury) colorless liquid; weak, sweetish odor; insoluble in water; easily soluble in ether and alcohol; MP (-80°C, -112°F approximately); BP (95°C, 203°F at 760 mmHg); DN (3.1874 g/mL at 20°C); LSG (3.2); VD (7.9); VP (50 mmHg at 20°C); (diethylmercury) colorless liquid; faint, sweet odor; insoluble in water; soluble in diethyl ether, but less soluble in ethanol; MP (data not available (very low)); BP (159°C, 318°F at 760 mmHg); DN (2.43 g/mL at 20°C); LSG (2.4); CP (182.8 J/K-mol liquid at 25°C); VD (8.9); VP (2 mmHg at 20°C); (ethylmercuric chloride) white, silvery, iridescent leaflets from ethanol; odorless solid; insoluble in water; soluble in chloroform; slightly soluble in ethanol and diethyl ether; MP (196 - 198°C, 384.8 - 388.4°F); BP (sublimes above 40°C, 104°F); DN (3.48 g/mL at 20°C); LSG (3.48); VD (9.2); VP (<<1 at 20°C).

**CHEMICAL PROPERTIES:** Chemical properties vary depending upon the specific (organo) alkyl mercury compounds. In general, most are stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with strong oxidizers, such as chlorine; liquid organo (alkyl) mercury will attack some forms of rubber, plastics, and coatings; FP (dimethylmercury and diethylmercury: data not available, ethylmercuric chloride: not applicable); LFL/UFL (data not available); AT (data not available); HF (dimethylmercury: 59.8 kJ/mol liquid at 25°C, diethylmercury: 30.1 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** Dimethyl and diethyl mercury are easily flammable when exposed to heat or flame; contact with strong oxidizing agents, such as chlorine, may cause fires and explosions; decomposition to flammable and explosive hydrocarbon gases will occur at elevated temperatures; toxic gases and vapors, such as toxic mercury fumes and carbon monoxide, may be released in a fire; use carbon dioxide, dry chemical, or foam for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, lacrimation, nausea, vomiting, irritates eyes, skin, upper respiratory tract and mucous membranes); skin absorption( irritability, tremors, memory problems, changes in vision or hearing); contact (skin burns, severe dermatitis, skin rashes, eye irritation); ingestion (nausea, vomiting, diarrhea, constipation, hypersalivation, loss of appetite, weight loss, fatigue).

**FIRST AID:** flush eyes thoroughly with large amounts of water for several minutes; wash affected areas of skin with plenty of soap or mild detergent and water; administer oxygen if breathing is difficult; perform artificial respiration if breathing has stopped; if this chemical has been swallowed, give large quantities of water ,then induce vomiting; get immediate medical attention..

**HUMAN TOXICITY DATA:** (diethyl mercury) inhalation - human LCLo 1040µg/m<sup>3</sup>/14W.

**ACUTE HEALTH RISKS:** irritation to eyes, skin, and upper respiratory tract; severe skin rash or burns; numbness; tingling of lips, hands, and feet; staggering; joint pain; narrowing of vision; hearing difficulties; emotional disturbances; spasticity; jerking movements of arms, legs, head or shoulders; bouts of groaning, shouting, or crying; dizziness; increased watering of mouth; watering of eyes; nausea; vomiting; diarrhea; constipation; loss of appetite; weight loss; fatigues; kidney injury has occurred; fatal poisoning has occurred due to exposure to alkyl mercurials.

**CHRONIC HEALTH RISKS:** central nervous system disturbances; paresthesia; blurred vision; speech difficulties; deafness; malaise (vague feeling of discomfort); constriction of the visual field; permanent damage to the brain; mental retardation and cerebral palsy in infants; significant developmental defects; severe dermatitis; skin sensitization has occurred.

**EXPOSURE GUIDELINES:** ACGIH TILV TWA (alkyl compounds) 0.01 mg/m<sup>3</sup>; ACGIH TLV STEL (alkyl compounds) 0.03 mg/m<sup>3</sup>; OSHA PEL TWA (alkyl compounds) 0.01 mg/m<sup>3</sup>; OSHA PEL CL (alkyl compounds) 0.04 mg/m<sup>3</sup>; NIOSH REL TWA (alkyl compounds) 0.01 mg/m<sup>3</sup> (skin); NIOSH REL STEL (alkyl compounds) 0.03 mg/m<sup>3</sup> (skin); IDLH (organo(alkyl) mercury compounds) 2 mg (as Hg)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; glove manufacturers have recommended viton<sup>®</sup> neoprene, neoprene, polyvinyl chloride (PVC), and butyl neoprene for protection against mercury; wear chemical safety goggles and face shield; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in high vapor concentrations; maintain eyewash fountains and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; if in solid form, collect in a dust pan and pour into plastic bag or sealed containers; sprinkle powdered sulfur on spill in order to determine whether mercury is still present (note; if it runs from yellow to brown, more clean-up is needed); sprinkle powdered zinc to suppress vaporization of small amounts of remaining mercury; if in liquid form, absorb small quantities on paper towels and evaporate in a fume hood; large quantities can be collected for reclamation or disposal in sealed containers.

**DISPOSAL AND STORAGE METHODS:** organo (alkyl) mercury compounds may be disposed of in sealed containers in a secured, sanitary landfill; store in tightly closed containers in a cool, well-ventilated area away from strong oxidizers, such as chlorine, keep away from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (none); label (none required).

**OTHER COMMENTS:** Methylmercury is generally produced by microorganisms in the water or soil, rather than made by human activity. Even though the use has been banned since the 1970's, methyl- and ethylmercury compounds were once used to protect seed grains from fungal infections. Phenylmercury compounds were used as antifungal agents in paints until 1991, when this use was also discontinued. Organo (alkyl) mercury may also be utilized as a wood, timber, and paper preservative.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 16; 19.

## MERCURY, VAPOR (Hg, 200.6)

**CAS/DOT IDENTIFICATION #:** 7439-97-6/UN2809

**SYNONYMS:** colloidal mercury, elemental mercury, hydrargyrum, liquid silver, metallic mercury, quicksilver

**PHYSICAL PROPERTIES :** shiny, silver-white liquid; odorless liquid; evaporates at room temperature to form mercury vapor, a colorless, odorless gas; insoluble in hydrochloric or similar acids; soluble in hot concentrated sulfuric acid; insoluble in water and inorganic solvents; MP (-38.89°C, -38°F); BP (356.9°C, 674.4°F); DN (13.534 g/cm<sup>3</sup> at 25°C); LSG

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(13.6); ST (484 dynes/cm at 25°C); CP (6.687 cal/mol-deg at constant pressure, 25°C); HV (14.652 kcal/mole at 25°C); VD (not applicable); VP ( $2 \times 10^{-3}$  mmHg at 25°C).

**CHEMICAL PROPERTIES:** pure mercury does not tarnish on exposure to air at ordinary temperatures; slowly oxidizes to mercuric oxide when heated to boiling point; forms alloys with most metals except iron; combines with sulfur at ordinary temperatures; reacts with nitric acid and hot, concentrated sulfuric acids; does not react with dilute hydrochloric acids, cold sulfuric acid, or alkalis; reacts with ammonia solution in air to form  $\text{Hg}_2\text{NOH}$ .

**EXPLOSION and FIRE CONCERNS:** noncombustible; slightly volatile at ordinary temperatures; NFPA rating (not rated); may explode on contact with 3-bromopropyne, ethylene oxide, lithium, peroxyformic acid, and chlorine dioxide; vapor ignites on contact with boron diiodophosphide; reacts violently with acetylenic compounds, metals, chlorine, chlorine dioxide, methyl azide, and nitromethane; incompatible with acetylene, ammonia, chlorine dioxide, azides, calcium, sodium carbide, lithium, rubidium, and copper; heating to decomposition emits toxic fumes of Hg; use water spray, fog, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (mood changes, inability to concentrate, memory loss, shaking or loss of feeling of the hand, tongue, or eyelid; discoloration of the cornea and lens of the eye; impairment of vision; kidney disease); contact (rash over the body, chills, swelling and irritation of hands, feet, nose, and cheeks, trouble sleeping, heavy sweating, and light sensitivity may all occur in children).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** inhalation-man TDLo 44,300  $\mu\text{g}/\text{m}^3/8\text{H}$ ; toxic effect: central nervous system, liver, MET; inhalation-woman TCLo 150 $\mu\text{g}/\text{m}^3/46\text{D}$ ; toxic effect: central nervous system, gastrointestinal tract; skin-man TDLo 129mg/kg/5H; toxic effect: ear, central nervous system, skin; immediately dangerous to life or health 28mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** pneumonitis; fever; tachypnea; cough; chest pain; cyanosis; diarrhea; vomiting; emphysema; hemorrhage; pneumothorax; lethargy; restlessness; respiratory effects; pulmonary function impairment; kidney damage; metallic taste in mouth; death.

**CHRONIC HEALTH RISKS:** central nervous system; depression; irritability; exaggerated response to stimulation; excessive shyness; insomnia; emotional instability; confusion; forgetfulness; excessive perspiration; uncontrolled blushing; tremors; trembling of fingers, eyelids, lips and tongue; swelling of salivary glands; stomatitis; gingivitis; loosening of the teeth; dark line on inflamed gums; formation of ulcers on lip and cheeks; degeneration of brain cortex; renal proteinuria; contact dermatitis; spontaneous abortions; sever leg cramps.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.050mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.050 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.050 mg/m<sup>3</sup>; IDLH 28mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** protective suit and rubber gloves are recommended; appropriate respirators operated in a positive pressure mode are needed in areas where exposure would be above the IDLH; wear chemical goggles and face shield when working with liquid; adequate shower facilities and eye wash fountains should be provided in the immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; turn off or lower any type of heat since mercury vaporization increases significantly with temperature; collect spills with special mercury vapor suppressants or special vacuums; push together beads of mercury with a squee-

gee, collect in a dust pan, and deposit in plastic bag or container; sprinkle powdered zinc in the spill area to suppress vaporization of remaining mercury; use a mercury vapor meter to assess airborne exposure and to determine whether the area can be reoccupied for normal use.

**DISPOSAL AND STORAGE METHODS:** waste must be manifested and shipped to a facility licensed to accept mercury-containing waste; store in tightly closed containers in a cool, well-ventilated area; keep away from ammonia, nickel and acetylene; secure in poison area.

**REGULATORY INFORMATION :** A1; Reportable Quantity (RQ): 1 lb (0.454 kg); DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in barometers, thermometers, hydrometers and pyrometers; used in fluorescent lamps, switches and mercury boilers; used in the manufacture of mercury salts, mirrors, pulp and paper, and oscillators; used as a component of zinc-carbon batteries as well as industrial and control instruments and amalgams (e.g. for dental preparations); laboratory use includes manometers, gauges, valves, seals, and navigational devices.

**KEY REFERENCES:** 3; 4; 5; 6; 15; 16; 18; 19.

## **MESITYL OXIDE (C<sub>6</sub>H<sub>10</sub>O, 98.16)**

**CAS/DOT IDENTIFICATION #:** 141-79-7/UN1229

**SYNONYMS:** isobutenyl methyl ketone, isopropylideneacetone, methyl isobutenyl ketone, 2-methyl-2-penten-4-one, 4-methyl-3-penten-2-one.

**PHYSICAL PROPERTIES:** colorless to light-yellow, oily liquid; darkens on standing; peppermint-like odor or odor of honey; at low temperatures, can be made to crystallize in petroleum ether; slightly soluble in water at 20°C; miscible in alcohol, ether, and most organic solvents; MP(-41.5°C, -42.7°C; note: also reported as -59°C (-74°F); BP(130°C, 266°F); DN(0.8569 g/mL liquid at 20°C); LSG(0.86); BULK DN (7.1 lb/gal at 20°C) VS(0.0060 poise at 20°C) HV(43.4 kJ/mol at 25°C); VD(3.38); REL DN vapor/air mixture (1.03 at 20°C); VP(8.7 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; polymerization may occur; can react with oxidizing materials when heated; attacks many plastics; FP(31°C, 87°F); LFL/UFL (1.4%, 7.2%); AT (344°C, 651°F) HC(data not found in literature).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; dangerous fire hazard; NFPA rating Health 3, Flammability 3, Reactivity 0; may form explosive vapor/air mixtures above 25°C; flashback along vapor trail may occur; can be presumed to form explosive peroxides; violent reaction with strong oxidants; reacts violently with 2-amino ethanol, chlorosulfonic acid, nitric acid, sulfuric acid, ethylene diamine, and oleum; combustion may produce toxic gases, including carbon monoxide and carbon dioxide; use dry chemical, alcohol resistant foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, dullness, cough, shortness of breath, conjunctivitis, irritates eyes, skin and respiratory tract); skin absorption (narcotic effects, effects upon liver, kidneys and lungs); contact (irritates all bodily tissues, serious eye damage, defatting of skin); ingestion (abdominal cramps, other symptoms parallel those of inhalation).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxy-

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gen; if breathing has stopped, provide artificial respiration; in case of ingestion rinse mouth and then give slurry of activated charcoal in water to drink; seek prompt medical attention.

**HUMAN TOXICITY DATA:** inhalation-human TLCo 25 ppm; toxic effect: eye; eye-human 25 ppm/15M.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory tract; irritation of tissues of mucous membranes; conjunctiva irritation; headache; dizziness; shortness of breath; cough; sore throat; dullness; narcosis; abdominal cramps; lowering of consciousness; coma.

**CHRONIC HEALTH RISKS:** prolonged exposure may have harmful effects on the liver, kidneys and lungs; may cause serious eye damage, including opaque cornea, keratoconus, and extensive necrosis of cornea; liquid may cause defatting of skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 15 ppm (60 mg/m<sup>3</sup>); ACGIH TLV STEL 25 ppm(100 mg/m<sup>3</sup>); OSHA PEL TWA 100 mg/m<sup>3</sup>; NIOSH REL TWA 10ppm (40 mg/m<sup>3</sup>); IDLH 1400 ppm (based on 10% of lower explosive limit).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles or face shield; above 25°C enclose operations and/or use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus in unknown concentrations or in IDLH conditions; maintain eye wash baths and safety showers in work area; for extra personal protection, use P3 filter respirator for toxic particles.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use appropriate foam to blanket release and suppress vapors; collect liquid in sealable containers or absorb in non-combustible materials (dry earth, sand or vermiculite); flush remaining material with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry location; maintain adequate ventilation; keep in the dark; outside storage is preferred; inside storage should be in a fireproof cabinet; separate from strong oxidants; avoid sunlight and other sources of heat.

**REGULATORY INFORMATION:** T120-a, T799-5000; AI; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose, vinyl resins, many gums, lacquers, stains, roll-coating inks, paint and varnish removers, and insect repellent; utilized in the manufacture of methyl isobutyl ketone.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 14.

### METHOXYCHLOR (C<sub>16</sub>H<sub>15</sub>Cl<sub>3</sub>O<sub>2</sub>, 345.66)

**CAS/DOT IDENTIFICATION #:** 72-43-5/none

**SYNONYMS:** p,p'-dimethyldiphenyltrichloroethane, dmdt, methoxy-ddt, 2,2-bis(p-methoxyphenyl)-1,1,1-trichloroethane, 1,1,1-trichloro-2,2-bis(p-methoxyphenyl)ethane.

**PHYSICAL PROPERTIES** : colorless to light-yellow crystals; dimorphic; soluble in alcohol and acetone; insoluble in water; solubilities in alcohol and acetone; insoluble in water; solubilities are approximately those of dichlorodiphenyltrichloroethane (DDT); MP (78°C, 172.4°F); BP (decomposes); DN (1.41 g/cm<sup>3</sup> at 20°C); SG (1.41); VD (12); VP (very low).

**CHEMICAL PROPERTIES**: combustible solid; resistant to heat; can react with oxidizers; less readily dehydrochlorinated than DDT by alcoholic alkali; FP (unknown); LFL/UFL (unknown); AT (unknown); HC (unknown).

**EXPLOSION and FIRE CONCERNS**: combustible, but difficult to burn; NFPA rating (NA); combustion by-products include carbon monoxide, carbon dioxide, and hydrogen chloride gas; heating to decomposition emits highly toxic fumes of Cl<sup>-</sup>; use dry chemical powder, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation or skin absorption (muscle weakness, liver dysfunction); skin contact (chloracne, tremors, convulsions, eye and skin burns).

**FIRST AID**: wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support or oxygen; if swallowed, wash out mouth immediately and seek medical attention..

**HUMAN TOXICITY DATA**: skin-human TDLo 2414 mg/kg; toxic effect: central nervous system; oral-human LDLo 6430 mg/kg.

**ACUTE HEALTH RISKS**: trembling, convulsions; mild kidney and liver damage; somnolence.

**CHRONIC HEALTH RISKS**: may alter genetic material and cause reproductive disorders; suspected carcinogen with experimental data; target organs; central nervous system, liver and kidneys.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>; NIOSH REL TWA potential occupational carcinogen; IDLH 5000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear special protective clothing, including chemical-resistant gloves; use chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP**: stop or control leak if possible; use water spray to cool and disperse vapors absorb liquid in noncombustible materials such as dry earth, sand or vermiculite; shovel solids into suitable dry containers.

**DISPOSAL AND STORAGE METHODS**: shovel solids into sealable containers for disposal in a designated landfill; absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry, well-ventilated area; separate from oxidizing materials and organic acids.

**REGULATORY INFORMATION**: CA2; S1; S24; S32-43; S50-b15; S61-c14; S62'-32; F2; F4; R1; R3; R4; R5; R6; R8; D waste # (D014); U waste # (U247); Reportable Quantity (RQ): 1 lb. (0.454 kg); Sf1; Sf3; CW1; CW2; A1; CAL.

**OTHER COMMENTS**: used as an insecticide against mosquitoes and house flies; recommended for use in dairy barns; may be used as a replacement for dichlorodiphenyltrichloroethane (DDT).

**KEY REFERENCES**: 3; 4; 5; 6; 7; 12; 13; 14; 19.

**2-METHOXYETHANOL (CH<sub>3</sub>OCH<sub>2</sub>CH<sub>2</sub>OH, 76.09)**

CAS/DOT IDENTIFICATION #: 109-86-4/UN1188

**SYNONYMS:** egme, ethylene glycol monomethyl ether, glycol monomethyl ether, methoxyhydroxyethane, methyl cellosolve<sup>®</sup>.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mild, ether-like odor; miscible with water, alcohols, ether, benzene, glycerol, acetone, ketones, glycols, and dimethyl formamide; MP (-85.1°C, -121°F); BP (124.44°C, 256°F at 760 mmHg); DN (0.9663 g/mL at 20°C); LSG (0.96 at 20°C); ST (30.84 mN/m at 25°C); HV (45.17 kJ/mol at 25°C); VD (2.62); VP (6.2 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; reported to dissolve aluminum from scratched or heated aluminum surfaces; conditions which may contribute to instability include distilling to dryness and excessive temperatures or prolonged reflux, such as in batch distillations; hazardous polymerization will not occur; can react with strong oxidizers and alkalies; FP (39°C, 102°F); LFL/UFL (1.8%, 14%); AT (286°C, 547°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; moderate explosion hazard; NFPA rating Health 2, Flammability 2, Reactivity 2; forms explosive vapor-air mixtures above flash point; flashback along vapor trail may occur; sensitive to static discharge; formation of explosive peroxides has been reported from auto-oxidation; contact with strong oxidizers may cause fire; incompatible with strong acids and high temperatures in the presence of strong bases; carbon dioxide and carbon monoxide may form when heated to decomposition; use dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, fatigue, drowsiness, change in motor activity, tremors, convulsions, nausea, vomiting, loss of appetite); skin absorption (headache, dizziness, weakness, lethargy, personality changes, mental dullness, disorientation, incoordination); contact (irritation, redness, pain); ingestion (nausea, vomiting, dizziness, weakness, hemorrhagic gastritis, liver damage, damage to kidneys is possible from ingestion of large quantities).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and give oxygen; if not breathing, administer artificial respiration; in case of ingestion, induce vomiting immediately and call a physician.

**HUMAN TOXICITY DATA:** oral-human LDLo 3380 mg/kg; inhalation-human TCLo 25 ppm; toxic effect: central nervous system.

**ACUTE HEALTH RISKS:** may cause irritation to skin, eyes and respiratory tract; headache; dizziness; fatigue; drowsiness; weakness; ataxia (muscular incoordination); tremors; anemic pallor; nausea; vomiting; loss of appetite; hemorrhagic gastritis; liver damage; pancreas damage; possible damage to kidneys; brain edema resulting in death has occurred in human exposure of 3g/kg.

**CHRONIC HEALTH RISKS:** prolonged exposure may cause injury to bone marrow and blood cells; may cause injury to kidney, liver and testes; suspected human reproductive hazard; possible birth defect hazard; severe neurological disabilities, including headache, dizziness, lethargy, weakness, personality changes, disorientation, apathy, and unequal pupil size.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (skin); OSHA PEL TWA 25 ppm (80 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.1 ppm (0.3 mg/m<sup>3</sup>)(skin); IDLH 200 ppm..

**PERSONAL PROTECTION:** wear rubber or neoprene gloves and additional protection including impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use splash-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use non-sparking tools and equipment, including explosion proof ventilation; in oxygen-deficient atmospheres, wear positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; absorb as much liquid as possible with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush remaining liquid with large amounts of water but not into spaces such as sewers because of danger of explosion; use water spray to cool and disperse vapor, and dilute spills to form nonflammable mixtures; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; atomize large amounts in a RCRA approved incinerator equipped with afterburner and scrubber; store in a cool, dry location; use only with adequate ventilation; outside storage is preferred; keep containers closed; containers should be bonded and grounded for transfers to avoid static sparks; separate from incompatibles; keep away from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** Sf3; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose, low viscosity cellulose acetate, natural and synthetic resins, some alcohol-soluble dyes, lacquers enamels and varnishes; also used in dyeing leather, sealing moisture-proof cellophane, in nail polishes, and in wood stains; useful as a jet-fuel deicing additive.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

## **2-METHOXYETHYL ACETATE (CH<sub>3</sub>COOCH<sub>2</sub>CH<sub>2</sub>OCH<sub>3</sub>, 118.15)**

**CAS/DOT IDENTIFICATION #:** 110-49-6/UN1189

**SYNONYMS:** acetic acid, 2-methoxyethyl ester, egme, ethylene glycol monomethyl ether acetate, glycol monomethyl ether acetate, 2-methoxyethanol acetate, methyl cellosolve<sup>®</sup> acetate.

**PHYSICAL PROPERTIES :** colorless liquid; pleasant, ether-like odor; soluble in water; miscible with common organic solvents and oils; dissolves gums and resins; MP (-65°C, -85°F); BP (145°C, 293°F); DN (1.0067 g/mL at 20°C); BULK DN (8.4 lb/gal at 20°C); LSG (1.01); VD (4.07); REL DN vapor/air mixture (1.01 (calculated) at 20°C); VP (2 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with strong oxidants, strong bases, strong acids and nitrates; FP (45°C, 113°F) LFL/UFL (1.7%, 8.2%); AT (392°C, 737.6°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid when exposed to heat or flame; moderately explosive; NFPA rating Health 1, Flammability 2, Reactivity 0; explosive

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vapor/air mixtures may be formed above 45°C; can react vigorously with oxidizing materials; incompatible with strong acids, alkalis and nitrates; heating to decomposition emits carbon dioxide and carbon monoxide; use powder, alcohol-resistant foam, water spray or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (eye lacrimation, cough, headache, dizziness, loss of consciousness); skin absorption (confusion, dizziness, drowsiness, headache, weakness); ingestion (abdominal pain, nausea, vomiting, weakness, confusion, dizziness, drowsiness, unconsciousness).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and give oxygen; if not breathing, administer artificial respiration; in case of ingestion, rinse mouth and call a physician.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 1000 mg/m<sup>3</sup>; toxic effect: eye, pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; may cause effects on the blood; affects central nervous system; eye lacrimation; cough; pulmonary changes; headache; dizziness; drowsiness; confusion; weakness; abdominal pain; nausea; vomiting; unconsciousness.

**CHRONIC HEALTH RISKS:** may have effects on the blood; liver damage; damage to kidneys; brain damage; possibly causes toxic effects upon human reproduction.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (24 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 25 ppm (120 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.1 ppm (0.5 mg/m<sup>3</sup>)(skin); IDLH 200 ppm.

**PERSONAL PROTECTION:** use impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; use a closed system of local exhaust ventilation above 45°C; use non-sparking tools and equipment, and explosion-proof electrical equipment; in oxygen-deficient atmospheres, wear positive pressure self-contained breathing apparatus; for extra personal protection, use a filter for organic vapors; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; absorb as much liquid as possible with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush remaining liquid with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; should be handled as a hazardous waste and sent to a RCRA approved incinerator; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; use only with adequate ventilation; outside storage is preferred; keep containers closed; containers should be bonded and grounded for transfers to avoid static sparks; separate from strong oxidants, strong bases, strong acids, and nitrates; keep away from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as an industrial solvent for nitrocellulose, cellulose acetate, various gums, waxes, resins, and oils; other uses include lacquers, photographic film, and textile printing.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### **METHYL ACETATE (CH<sub>3</sub>COOCH<sub>3</sub>, 74.09)**

**CAS/DOT IDENTIFICATION #:** 79-20-9/UN1231

**SYNONYMS:** acetic acid, methyl ester, methyl ester of acetic acid, methyl ethanoate.

**PHYSICAL PROPERTIES :** colorless liquid; pleasant, fruity odor; moderately soluble in water; miscible with common hydrocarbon solvents; MP (-99°C, -146°F); BP (58°C, 136°F); DN (0.92438 g/mL at 20°C); BULK DN (7.76 lb/gas at 20°C); LSG (0.93); ST (24.73 mN/m at 25°C); VS (0.364 mPa-s at 25°C); CP (141.9 J/K-mol liquid at 25°C); HV (32.29 kJ/mol at 25°C); VD (2.55); VP (170 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable at room temperature in sealed containers; hazardous polymerization will not occur; reacts slowly with water to form acetic acid and methanol; can react with strong oxidizers; nitrates, alkalis, and acids; FP (-10°C, 14°F); LFL/UFL (3.1%, 16%); AT (454°C, 849°F); HC (-1.4610 x 10<sup>9</sup> J/kmol); HF (-445.8 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** extremely flammable liquid and vapor; vapor may cause flash fire; NFPA rating Health 1, Flammability 3, Reactivity 0; dangerous fire hazard; vapor-air mixtures are explosive above flash point; sealed containers may rupture when heated; sensitive to static discharge; contact with strong oxidizers may result in fire; incompatible with nitrates, alkalis, and acids; carbon dioxide and carbon monoxide may form when heated to decomposition; use dry chemical, alcohol foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, drowsiness, difficulty breathing, chest tightness, palpitation, conjunctivitis, irritates eyes, nose, and respiratory tract); skin contact (dryness, cracking, skin irritation, loss of natural oils); eye contact (redness, tearing, severe irritation); ingestion (abdominal pain, nausea, vomiting, severe lung damage due to aspiration into lungs).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and give oxygen; if not breathing, administer artificial respiration; in case of ingestion, do not induce vomiting; if vomiting occurs spontaneously, keep head below hips to prevent lung aspiration; get immediate medical attention.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 15,000 mg/m<sup>3</sup>; toxic effect: irritant effects on the skin, eyes, and mucous membranes.

**ACUTE HEALTH RISKS:** irritation to eyes, nose, and respiratory tract; narcosis; dizziness; shortness of breath; irregular heartbeat; depression; central nervous system depression; eye inflammation; nervous irritation; chest tightness; palpitation; difficulty breathing; headache; drowsiness; conjunctivitis; abdominal pain; nausea; severe lung damage; skin irritation; causes loss of natural oils from skin.

**CHRONIC HEALTH RISKS:** may cause dryness, cracking and skin irritation; affects central nervous systems; causes eye irritation; optic nerve damage is the predominant hazard; chronic effects may be similar to methanol.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm; ACGIH TLV STEL 250 ppm; OSHA PEL TWA 200 ppm (610 mg/m<sup>3</sup>); NIOSH REL TWA 200 ppm (610 mg/m<sup>3</sup>); NIOSH REL STEL 250 ppm (760 mg/m<sup>3</sup>); IDLH 3100 ppm..

**PERSONAL PROTECTION:** use impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles where splashing is possible; a system of local exhaust ventilation is recommended to control emission at the source and to prevent dispersion into general work area; use non-sparking tools and equipment, and explosion-proof electrical equipment; in oxygen-deficient atmospheres, wear positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; absorb liquid with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush remaining liquid with large amounts of water but not into spaces such as sewers because of danger of explosion; use water spray to cool and reduce vapors, and to flush spills away from exposures; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** handle as hazardous waste and send to a RCRA approved incinerator or dispose of in a RCRA approved waste facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; use only with adequate ventilation; outside storage is preferred; keep containers closed; containers should be bonded and grounded for transfers to avoid static sparks; isolate from incompatible substances; keep away from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** T130-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose, acetylcellulose, and many oils and resins; also used in the manufacture of artificial leather; other uses include paint remover compounds, lacquer solvents, and synthetic flavoring.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

## **METHYL ACETYLENE (CH<sub>3</sub>C=CH, 40.07)**

**CAS/DOT IDENTIFICATION #:** 74-99-7/UN1954

**SYNONYMS:** allylene, propine, propyne, 1-propyne.

**PHYSICAL PROPERTIES :** colorless, liquefied gas; sweet odor; moderately soluble in water; soluble in ethanol and diethyl ether; gas is heavier than air and may travel along the ground; MP (-102.7°C, -153°F); BP (-23.2°C, -10°F); DN (1.787 g/L gas at 0°C, 0.70 g/mL liquid at 20°C); VD (1.41); VP (3876 mmHg at 20°C); SV (9.7 ft<sup>3</sup>/lb at 70°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; undergoes acid-catalyzed hydration to yield ketones; completely hydrogenated in the presence of metal hydrogenation catalysts (e.g., Pt, Pd, Ni, or Rh), yielding alkanes; reacts with hydrogen halides to give alkenyl halides; produces carboxylic acids when subjected to ozonolysis; FP (flammable gas); LFL/UFL (1.7%, unknown); AT (unknown); HF (184.9 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** extremely flammable gas; dangerous fire risk; NFPA rating Health 2, Flammability 4, Reactivity 2; gas/air mixtures are explosive; an explosion may result due to heating of liquid containing cylinders to 95°C (203°F); distant ignition is

possible; electrostatic charges can be generated as a result of flow, agitation, etc.; can react vigorously with oxidizing materials; reaction with silver nitrate yields a product that ignites at 150°C (302°F); methyl acetylene-propadiene (MAPP) gas mixture containing 30% propyne is similar to ethylene in potential hazards; incompatible with strong oxidizers (such as chlorine) and copper alloys; can decompose explosively at 4.5 to 5.6 atmospheres of pressure; in case of fire, let the fire burn itself out; in other cases, use water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, nausea, asphyxia, lowering of consciousness, irritates respiratory tract); contact (anesthetic effects, liquid may cause frostbite)

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; on frostbite, rinse and then wash affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and give oxygen; administer artificial respiration; if indicated get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to respiratory system; headache; dizziness; nausea; tremors; hyper-excitability; anesthesia; can cause suffocation by lowering oxygen content of air in confined areas; rapid evaporation of liquid may cause frostbite; could cause lowering of consciousness.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm (1640 mg/m<sup>3</sup>); OSHA PEL TWA 1000 ppm (1650 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (1650 mg/m<sup>3</sup>); IDLH 1700 ppm.

**PERSONAL PROTECTION:** use impervious protective clothing, including boots, cold-insulating gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; a closed system of local exhaust ventilation is preferred; use non-sparking hand-tools, explosion-proof electrical equipment and lighting; prevent build-up of electrostatic charges by grounding; for extra personal protection, wear a chemical protection suit including self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; stop or control the leak, if possible; use appropriate foam to blanket release and suppress vapors; absorb liquid in noncombustible materials (e.g., dry earth, sand, vermiculite) for proper disposal; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** pipe gas into incinerator, or lower into a pit and allow it to burn away; atomize large amounts of liquid in a suitable combustion chamber equipped with afterburner and scrubber; store in a cool, dry location; use only with adequate ventilation; outside storage is preferred; store cylinders upright; container should be bonded and grounded, if in liquid state, to prevent build-up of electrostatic charges; isolate from incompatibles; avoid sparks and open flames.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (2.1); labels (flammable gas).

**OTHER COMMENTS:** use as a specialty fuel and as a chemical intermediate in many organic syntheses.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 12; 14.

**METHYL ACETYLENE - PROPADIENE MIXTURE (C<sub>3</sub>H<sub>4</sub>, 40.1)****CAS/DOT IDENTIFICATION #:** 59355-75-8/UN1060

**SYNONYMS:** mapp gas, methyl acetylene - allene mixture, methyl acetylene - propadiene mixture (stabilized), propadiene methyl acetylene, propyne - allene mixture, propyne - propadiene mixture.

**PHYSICAL PROPERTIES:** colorless, liquefied compressed gas; strong, characteristic, foul odor; insoluble in water; MP (-136°C, -213°F); BP (-37.8 to -20°C, -36 to -4°F); DN (0.576 g/mL liquid at 15°C); VD (1.48); VP (> 1 atm, > 760 mmHg at 20°C); OT (100 ppm).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with strong oxidizers; incompatible with copper alloys; will attack some forms of plastics, rubber, and coatings; FP (NA, gas); LFL/UFL (3.4%, 10.8%); FT (in oxygen)(2925°C, 5297°F).

**EXPLOSION and FIRE CONCERNS:** flammable gas mixture; dangerous fire risk; NFPA rating (not rated); contact with strong oxidizers may cause fire and explosion; explosive compounds are formed on contact with alloys containing more than 67% copper at high pressure; toxic gases and vapors, such as carbon monoxide and carbon dioxide, may be released in a fire; in order to fight fire, stop flow of gas.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory system, anesthesia, disorientation, excitement, confusion); contact (liquid may cause frostbite).

**FIRST AID:** flush eyes thoroughly with large amounts of water for several minutes; if eye tissue is frozen, seek prompt medical attention; wash affected areas of skin with plenty of soap and water; if frostbite has occurred, get immediate medical attention, administer oxygen if breathing is difficult; provide respiratory support if breathing has stopped.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to respiratory system; anesthesia; excitement; confusion; disorientation; liquid may cause frostbite.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm (1640 mg/m<sup>3</sup>); ACGIH TLV STEL 1250 ppm (2050 mg/m<sup>3</sup>); OSHA PEL TWA 1000 ppm (1800 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (1800 mg/m<sup>3</sup>); NIOSH REL STEL 1250 ppm (2250 mg/m<sup>3</sup>); IDLH 3400 ppm (based on 10% of lower explosive limit).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles, in combination with full-facepiece respirator (gas mask); appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in IDLH conditions or in unknown concentrations; maintain eyewash fountains and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak; stop flow of gas if possible; if source of leak is a cylinder, cautiously remove leaking cylinder to a safe location in the open air, and allow the cylinder to empty; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** Methyl acetylene-propadiene mixture may be disposed of by burning at a safe location or in a suitable combustion chamber equipped with

appropriate effluent gas cleaning device; store in a cool, dry location; maintain adequate ventilation; outside or detached storage is preferred for cylinders; inside storage should be in a standard flammable liquids storage room or cabinet; separate from oxidizing materials and alloys of copper.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (2.1); label (flammable gas).

**OTHER COMMENTS:** Methyl Acetylene - Propadiene is a mixture containing 60-66.5% methylacetylene and propadiene, with the balance being propane and butane. It is most commonly used as an industrial fuel gas for welding, brazing, cutting, heat treating, and metabolizing.

**KEY REFERENCES:** 4; 5; 6; 7; 16; 18.

### **METHYL ACRYLATE (CH<sub>2</sub>=CHCOOCH<sub>3</sub>, 86.10)**

**CAS/DOT IDENTIFICATION #:** 96-33-3/UN1919

**SYNONYMS:** acrylic acid methyl ester, methoxycarbonylethylene, methyl ester of acrylic acid, methyl propenoate, methyl-2-propenoate, propenoic acid methyl ester.

**PHYSICAL PROPERTIES :** clear, colorless liquid; sharp, sweet, fruity odor; floats on water; soluble in alcohol and ether; practically insoluble in water; forms an azeotrope with 9.5% water at 73°C and 49.0% methanol at 61°C; MP (-77°C, -106°F); BP (81°C, 177°F); DN (0.9561 g/mL at 20°C); LSG (0.96); ST (24.2 dynes/cm at 20°C); VS (0.482 cP at 70°C); CP (158.8 J/K-mol liquid at 25°C); HV (8.25 kcal/mol); VD (2.97); VP (68.2 mmHg at 20°C); OT (20 ppm).

**CHEMICAL PROPERTIES:** flammable liquid; easily polymerizes on standing; usually contains an inhibitor such as hydroquinone to prevent polymerization; polymerization process may be speeded up by elevated temperature, oxidizers, and peroxides; reacts with strong acids and alkalis; FP (-3°C, 27°F); LFL/UFL (2.8%, 25%); AT (468°C, 875°F); HC (502.88 kcal/mol); HF (-362.2 kJ/mol at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 3, Flammability 3, Reactivity 2; flashback along vapor trail may occur; vapor may explode if ignited in a confined area; containers may rupture violently when heated; may polymerize explosively above 21°C (70°F); hazardous polymerization may be caused by heat, light, and peroxides; a storage hazard; forms peroxides, which may initiate exothermic polymerization; reacts vigorously with oxidizing materials; vapors are uninhibited and may form polymers in vents and other confined spaces; toxic gases and vapors; such as carbon monoxide, may be released in a fire; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, nausea, vomiting, confusion, unconsciousness); contact (severe respiratory irritation, lacrimation, severe skin burns); ingestion (irritates gastrointestinal tract).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 75 ppm; toxic effect: nose, eyes, pulmonary system.

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**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; headache; nausea; vomiting; confusion; dizziness; unconsciousness.

**CHRONIC HEALTH RISKS:** lung, liver, and kidney damage; may alter genetic material; olfactory effects; eye effects; severe respiratory damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm(skin); OSHA PEL TWA 20 ppm (35 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10 ppm (35mg/m<sup>3</sup>)(skin); IDLH 250 ppm

**PERSONAL PROTECTION:** wear chemical protective suit with self-contained breathing apparatus; chemical resistant gloves are recommended; wear splash-proof safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in a fume hood; absorb large quantities with noncombustible materials such as dry earth or sand; flush remaining methyl acrylate with large amounts of water but not into confined spaces such as sewers because of danger of explosion; atomize large amounts in a suitable combustion chamber; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dissolve in more flammable solvent and burn in incinerator equipped with effluent gas cleaning device; dilute concentrations may be adequately treated by sewage organisms but should not be allowed to enter sewers systems because of possibility of explosion; store in a cool, dry location; separate from oxidizers, peroxides or other initiators.

**REGULATORY INFORMATION:** S<sub>3</sub>; A<sub>1</sub>; C<sub>AL</sub>; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** utilized as a monomer, polymer, or copolymer; the monomer in the manufacture of leather finish resins, textile and paper coatings, and plastic films; primary use in production of acrylic and modacrylic fibers; produces the hardest resin of the acrylate ester series.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 10; 11; 13; 14.

### METHYLAL (CH<sub>3</sub>OCH<sub>2</sub>OCH<sub>3</sub>, 76.11)

**CAS/DOT IDENTIFICATION #:** 109-87-5/UN1234

**SYNONYMS:** dimethoxymethane, dimethyl formal, formal, formaldehyde dimethylacetal, methoxymethyl, methyl ether, methylene dimethyl ether.

**PHYSICAL PROPERTIES :** colorless, clear liquid; chloroform-like odor; pungent taste; miscible with alcohol, ether, and oils; soluble in water at 20°C to extent of 32 wt%; soluble in all proportions in acetone, benzene, and other organic solvents; MP (-105°C, -157°F); BP (43.9°C, 111°F); DN (0.8593 g/mL at 20°C); LSG (0.86); ST (21.1 dynes/cm at 20°C); CP (162.0 J/K-mol liquid at 25°C); HV (28.89 kJ/mol at 25°C); VD (2.63); VP (400 mmHg at 25°C).

**CHEMICAL PROPERTIES:** flammable liquid; volatile liquid; hydrolyzes readily in presence of acids to generate aldehydes; can react vigorously with strong oxidizers; FP (-32.2°C, -26°F); LFL/UFL (2.2%, 13.8%); AT (237°C, 459°F); HC (-10,970 Btu/lb, -6,100 cal/g, -255 x 10<sup>5</sup> J/kg); HF (-377.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 2, Flammability 3, Reactivity 2; flashback along vapor trail may occur; vapor may be explosive when ignited

in a confined area; may ignite or explode when heated with oxygen; very dangerous fire hazard; containers may explode in fire; heating to decomposition may produce irritating gases; incompatible with strong oxidizers and acids; use foam, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (narcosis, anesthesia, irritates eyes, nose and throat); contact (irritates eyes and skin); ingestion (depression of central nervous system, injury to kidneys and liver).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink water or milk, and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** mild irritation of eyes and upper respiratory system; irritation of skin; anesthesia; narcosis in high concentrations; central nervous system depression.

**CHRONIC HEALTH RISKS:** injury to lungs and liver; damage to the kidneys and heart.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm; OSHA PEL TWA 1000 ppm (3100 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (3100 mg/m<sup>3</sup>); IDLH 2200 ppm.

**PERSONAL PROTECTION:** wear special protective clothing, such as impervious apron and boots; rubber gloves are recommended; use chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and cautiously evaporate in a fume hood; large quantities can be collected and atomized in a suitable combustion chamber; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** pour on ground in open air and ignite from distance or allow to evaporate; dissolve in higher alcohol, benzene or petroleum ether, and atomize in suitable combustion chamber; store in a cool, dry location with adequate ventilation; separate from oxidizing materials and avoid sunlight.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for adhesives and protective coatings; used in perfumery industry and in the manufacture of artificial resins useful in organic syntheses, special-purposes fuel, and in reaction medium for Grignard reactions; has also been used externally as ointment.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 14.

### **METHYL ALCOHOL (CH<sub>3</sub>OH, 32.1)**

**CAS/DOT IDENTIFICATION #:** 67-56-1/1230

**SYNONYMS:** carbinol, methanol, methyl hydroxide, monohydroxymethane, wood alcohol, wood naphtha, wood spirit.

**PHYSICAL PROPERTIES** : clear, colorless liquid; very mobile liquid; slight alcoholic odor when pure; pungent odor when crude; miscible with ethanol, ether, benzene, ketones and most organic solvents; completely miscible in water at 20°C; soluble in acetone and chloroform; dissolves many inorganic salts; forms azeotropes with many compounds; MP (-97.8°C, -144°F); BP (64.7°C, 148.5°F); DN (0.8100 g/mL at 0°C, 0.7915 g/mL at 20°C, 0.7866 g/mL at 25°C); LSG (0.79); ST (22.61 mN/m at 20°C); VS (0.614 mPa-sec); SH (0.595-0.605 at 20-25°C); HV (39.2 kJ/mol); VD (1.11); VP (100mmHg at 21.2°C); OT (> 2000 ppm).

**CHEMICAL PROPERTIES**: highly polar liquid; burns with nonluminous, bluish flame; reacts vigorously with oxidizing agents; FP (12°C, 54°F); LFL/UFL (6.0%, 36.5%); AT (470°C, 878°F); HC (723 kJ/mol).

**EXPLOSION and FIRE CONCERNS**: flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 0; dangerous fire hazard; explosive in vapor form; reacts explosively with chloroform and sodium methoxide and diethyl zinc; reacts violently with alkyl aluminum salts, acetyl bromide, chloroform and sodium hydroxide, chloroform and potassium hydroxide, nitric acid and perchloric acid; reacts vigorously with oxidizing materials; incompatible with potassium, magnesium, bromine, chlorine, sodium hypochlorite, barium perchlorate, hydrogen peroxide, potassium tert-butoxide, carbon tetrachloride and metals, and dichloromethane; decomposition emits toxic fumes of carbon monoxide and carbon dioxide; flashback along vapor trail may occur; use dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (dizziness, headache, breathing difficulty, loss of consciousness); skin absorption (nausea, drowsiness, vertigo); ingestion (vomiting, gastric disturbances, eye damage).

**FIRST AID**: wash eyes immediately with large amounts of water; wash skin immediately with water; provide respiratory support.

**HUMAN TOXICITY DATA**: oral-human 428 mg/kg; toxic effect: central nervous system, pulmonary system; oral-human LDLo 143 mg/kg; toxic effect: eye, pulmonary system, gastrointestinal tract; inhalation-human TCLo 86,000 mg/m<sup>3</sup>; toxic effect: eye, pulmonary system; inhalation-human TCLo 300 ppm; toxic effect: eye, central nervous system, pulmonary system; oral-man LDLo 6422 mg/kg; toxic effect: central nervous system, pulmonary system, gastrointestinal tract; oral-man TDLo 3429 mg/kg; toxic effect: eye; oral-woman TDLo 4g/kg; toxic effect: eye, pulmonary system, gastrointestinal tract; dni-human lymphocyte 300mmol/L.

**ACUTE HEALTH RISKS**: irritation of eyes, skin and upper respiratory tract; headache; fatigue; drowsiness; dizziness; light headedness; vertigo; nausea; vomiting; optic nerve damage; blindness; circulatory collapse; respiratory failure; death.

**CHRONIC HEALTH RISKS**: gastric and visual disturbances; visual impairment; moderately toxic via all routes at moderate concentration levels.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 200 ppm; ACGIH TLV STEL 250 ppm (skin); OSHA PEL TWA 200 ppm (260mg/m<sup>3</sup>); OSHA PEL STEL 250 ppm (skin); NIOSH REL TWA 200 ppm (260 mg/m<sup>3</sup>); NIOSH REL STEL 250 ppm (325 mg/m<sup>3</sup>)(skin); IDLH 6000 ppm.

**PERSONAL PROTECTION**: wear rubber protective clothing, polyvinyl plastic or neoprene aprons, rubber boots, and chemical-resistant gloves; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** apply a fluorocarbon water foam to spill to diminish vapor; absorb as much as possible with noncombustible materials such as hycar and carbopol; materials such as polyester, urethane foam, and seagoing epoxy putty are recommended for plugging leaking containers of methanol; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or ashes, and cautiously ignite small amounts in open areas; mix with a flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry, well-ventilated place; outside storage preferred; inside storage should be in a standard flammable liquids storage room or cabinet.

**REGULATORY INFORMATION:** CA2; S10; U waste # (U154); Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sf1; Sf3; A1; CAL; DOT hazard class/division (3); labels (flammable liquid, poison).

**OTHER COMMENTS:** used as an industrial solvent; used as a raw material in the manufacture of formaldehyde; used as an ingredient of gasoline and diesel oil antifreezes; also used as an octane booster in gasoline; used as a solvent in the manufacture of cholesterol, streptomycin, vitamins, hormones, and other pharmaceuticals.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 13; 14; 19.

### **METHYLAMINE (CH<sub>3</sub>NH<sub>2</sub>, 31.07)**

**CAS/DOT IDENTIFICATION #:** 74-89-5/UN1061 anhydrous, UN1235 aqueous

**SYNONYMS:** aminomethane, anhydrous methylamine, aqueous methylamine, carbimamine, methanamine, monomethylamine.

**PHYSICAL PROPERTIES :** colorless gas or liquid; a liquid below 21°F; powerful ammonia-like odor; usually encountered as strong aqueous solution; fuming liquid when cooled in ice and salt mixture; soluble in alcohol; miscible with ether; very soluble in water; forming very strong alkaline solution; anhydrous material floats and boils on water as it mixes; MP (-94°C, -136°F); BP (-6°C, 21°F); DN (0.699 g/mL at -10.8°C); LSG (0.70); ST (23.0 dynes/cm at -20°C); VS (0.180 mPa-s at 25°C); CP (102.1 J/K-mol liquid at 25°C); HV (23.37 kJ/mol at 25°C); VP (2622 mmHg at 25°C); OT (20-100 ppm).

**CHEMICAL PROPERTIES:** corrosive to copper and zinc alloys, aluminum and galvanized surfaces; may react with acids, strong oxidizers, chlorine, hypochlorite, halogenated compounds, reactive organic compounds, and some metals; reactive with mercury and nitrosating compounds; FP (0°C, 32°F); LFL/UFL (4.9%, 20.7%); AT (430°C, 806°F); HC (253.5 kcal/gmol liquid at 25°C); HF (-47.3 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable gas; NFPA rating Health 3, Flammability 4, Reactivity 0; aqueous solutions are flammable unless diluted extensively; very dangerous fire hazard; explosive when exposed to heat or flame; flashback along vapor trail may occur; vapor may explode if ignited in enclosed area; container may rupture violently in fire; poisonous gases may be produced in fire; forms an explosive mixture with nitromethane; incompatible with mercury, strong oxidizers, and copper and zinc alloys; heating to decomposition emits carbon monoxide, carbon dioxide, hydrocarbons, toxic oxides of nitrogen, and toxic amine vapors; use water spray, carbon dioxide, dry chemical, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritation of nose and throat, violent sneezing, burning sensation in throat, coughing, difficulty in breathing, pulmonary congestion, pulmonary

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edema, bronchitis, conjunctivitis); contact (severe eye burns, blindness, skin burns, dermatitis); ingestion (burns of the mouth, throat, and esophagus).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin immediately with copious amounts of soap and water; provide oxygen or respiratory support; if ingested, dilute with large amounts of water or milk.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; nausea; coughing; pulmonary edema; pulmonary congestion; violent sneezing; burning sensation in throat; difficulty in breathing; bronchitis.

**CHRONIC HEALTH RISKS:** conjunctivitis; corneal damage; dermatitis; blindness; target organs: eyes, skin, and respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; ACGIH TLV STEL 15 ppm; OSHA PEL TWA 10 ppm (12 mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (12mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** rubberized outerwear is required; wear safety goggles and self-contained breathing apparatus; air lines or ammonia canister masks are required; equipment should not have copper, zinc, aluminum, or galvanized parts; emergency showers and eyewash baths should be provided in the immediate work area.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute to form non-flammable mixtures; neutralize dilute spills with five percent sulfuric acid; spill may also be covered with sufficient sodium bisulfate and sprinkled with water; absorb as much as possible in noncombustible materials such as dry earth or sand; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** cover contaminated amine with sufficient layer of sodium bisulfate; spray with water, neutralize and route to sewage plant; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; absorb in dry earth or sand and place in a sanitary landfill; store in a cool, dry, noncombustible location; separate from oxidizing materials, acids, and sources of halogens.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, flammable gas(UN1061)); DOT hazard class/division (3); labels (flammable liquid, corrosive (UN1235)).

**OTHER COMMENTS:** used in organic synthesis for introducing the methylamino group; intermediate for accelerators, dyes, pharmaceuticals, insecticides, and fungicides; useful as a fuel additive, polymerization inhibitor, component of paint removers, photographic developer, rocket propellant, and solvent; possible uses in solvent extraction systems.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 13; 14.

### **METHYL n-AMYL KETONE (CH<sub>3</sub>CO(CH<sub>2</sub>)<sub>4</sub>CH<sub>3</sub>, 114.21)**

**CAS/DOT IDENTIFICATION #:** 110-43-0/UN1110

**SYNONYMS:** amyl methyl ketone, n-amyl methyl ketone, 2-heptanone, methyl amyl ketone, methyl pentyl ketone.

**PHYSICAL PROPERTIES :** colorless to water-white liquid; mobile liquid; penetrating, banana-like fruity odor; slight solubility in water; miscible with most organic solvents;

soluble in alcohol and ether; MP (-35.5°C, -32°F); BP (149°C, 300°F); DN (0.8197 g/mL at 15°C); LSG (0.82); ST (26.12 mN/m at 25°C); VS (0.714 mPa·s at 25°C); HV (47.24 kJ/mol at 25°C); VD (3.94); VP (2.6 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react with strong oxidizing agents; will attack some forms of plastic; FP (39°C, 102°F); LFL/UFL (1.1% at 151°F, 7.9% at 250°F); AT (532.8°C, 991°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid and vapor; NFPA rating Health 1, Flammability 2, Reactivity 0; explosive vapor-air mixtures may be formed above 48°C (118°F); flashback along vapor trail may occur; closed containers may explode when heated; sensitive to static discharge; contact with strong oxidizers may cause fire; may form explosive peroxides; attacks some forms of plastics; incompatible with strong acids, alkalis, and oxidizers; hazardous decomposition products include carbon monoxide and carbon dioxide; use alcohol-resistant foam, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, dizziness, headache, narcosis, blurred vision, irritates respiratory tract, irritates mucous membranes, unconsciousness); skin contact (liquid defats the skin, may cause dermatitis); ingestion (nausea, vomiting, gastrointestinal irritation, headache, dizziness, central nervous system depression).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; if not breathing, provide respiratory support; in case of ingestion, induce vomiting; immediately get immediate medical attention..

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes and mucous membranes; severe irritation of respiratory system; cough; headache; dizziness; may cause narcosis; blurred vision; gastrointestinal irritation; nausea; vomiting; depression of central nervous system; lowering of consciousness; coma.

**CHRONIC HEALTH RISKS:** prolonged contact may cause defatting of skin and dermatitis; targets central nervous system, skin and respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (233 mg/m<sup>3</sup>); OSHA PEL TWA 100 ppm (465mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (465mg/m<sup>3</sup>); IDLH 800 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles; above 48°C, use a closed system of local exhaust ventilation and explosion-proof electrical equipment; use positive pressure self-contained breathing apparatus in instances where the exposure levels are exceeded or unknown; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill if possible; use water spray to cool and reduce vapors; in case of spill, soak up with dry earth, sand, or other non-combustible absorbent material and place into chemical waste container for proper disposal; flush area with water, preventing entrance into drains, sewer systems, or natural water supplies; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; use with adequate ventilation; stor-

age should be in a standard flammable liquids storage room or cabinet; keep container tightly closed; container should be bonded and grounded when transferring liquid; separate from strong oxidizing agents.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose lacquers; also used as synthetic flavoring; useful in perfumery industry, as a constituent of artificial carnation oils.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### METHYL BROMIDE (CH<sub>3</sub>Br, 94.95)

**CAS/DOT IDENTIFICATION #:** 74-83-9/UN1062

**SYNONYMS:** bromomethane, monobromomethane, terabol, zytex.

**PHYSICAL PROPERTIES :** colorless, transparent liquid or gas; liquefied compressed gas below 38°F; usually odorless; chloroform-like odor at high concentrations; burning taste; freely soluble in alcohol, acetone, chloroform, ether, carbon disulfide, carbon tetrachloride, and other common organic solvents; slightly soluble in water; MP (-93°C, -135°F); BP(4°C, 39°F); DN(1.732 g/mL at 0°C); LSG (1.73); ST (22.36 dynes/cm); VS (0.397 cP at 0°C); CP (132.3 J/gmol-K liquid at 25°C); HV (23.91 kJ/gmol); VD(3.27); VP(1250 mmHg at 20°C); OT (80 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES** very stable; will not polymerize; reacts with aluminum, magnesium and strong oxidizers; attacks aluminum to form aluminum trimethyl; nonflammable in air but burns in oxygen; FP (none); LFL/UFL (10%, 16%); AT (537°C, 999°F); HC (-705.4 kJ/mol); HF (-54.9 kJ/gmol liquid at 25°C, -35.5 kJ/gmol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable gas, but only in presence of a high energy source of ignition; NFPA rating Health 3, Flammability 1, Reactivity 0; moderate explosion hazard when exposed to sparks or flame; explosive mixtures with air are formed within a narrow flammability range at atmospheric pressure; presence of aluminum, magnesium, zinc and their alloys enhances the explosive sensitivity in air; incompatible with active metals, dimethyl sulfoxide, ethylene oxide, plastics, rubber, alkali metals, aluminum and its alloys and all strong oxidizers; decomposition emits carbon monoxide, carbon dioxide, and hydrogen bromide gas; use foam, water spray, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, vomiting, nausea, abdominal pain); skin absorption (pulmonary damage, central nervous system damage); contact (eye irritation, skin irritation, vesiculation).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TClO 35ppm; toxic effect: gastrointestinal tract; inhalation-man LClO 60,000ppm/2H; inhalation-child LClO 1 mg/m<sup>3</sup>/2H.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; headache; vertigo; dizziness; nausea; vomiting; anorexia; abdominal pain; weakness; slurring of speech; mental confusion; convulsions and shaking; paralysis; staggering gait; hand tremor; breathing

difficulty; pulmonary edema; visual disturbance; coughing; wheezing; laryngitis; increased bromide ion concentration in blood; circulatory collapse; coma; death from respiratory collapse.

**CHRONIC HEALTH RISKS:** damage to eyes, liver, kidneys, and lungs; human mutation data reported; possible carcinogen; effects are cumulative.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5ppm (skin); OSHA PEL TWA 5ppm (skin), OSHA PEL CL 20 ppm (80 mg/m<sup>3</sup>) (skin); NIOSH REL TWA reduce to lowest feasible level; IDLH 250 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves constructed from tetrafluoroethylene polymer; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; evacuate danger area; ventilate area of leak or spill; use fine water spray to disperse vapors; water jet should never be directed on liquid; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; store in a cool location; maintain adequate ventilation along floor; fire-proof if in building; separate from strong oxidants, aluminum and cylinders containing oxygen.

**REGULATORY INFORMATION:** CA2; F1; R3-43; R3; R4; R5; U waste #(U029); Reportable Quantity (RQ): 1000 lbs (454 kg); Sf1; Sf2; CW4; CW5; A1; A5; CAL; DOT hazard class/division (2.3) labels (poison gas).

**OTHER COMMENTS:** used as an insect fumigant; also used as a soil fumigant; used as a wool degreaser; used in extracting oils from nuts and seeds; used as a methylating agent and a fire extinguisher agent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 12; 13; 14; 19.

## **METHYL CHLORIDE (CH<sub>3</sub>Cl, 50.49)**

**CAS/DOT IDENTIFICATION #:** 74-87-3/UN1063

**SYNONYMS:** chloromethane, monochloromethane, RCRA waste number U045.

**PHYSICAL PROPERTIES :** colorless gas; compresses to a colorless liquid; ethereal odor; odor not noticeable even at dangerous concentrations; sweet taste; miscible with chloroform, ether, and glacial acetic acid; soluble in alcohol, benzene, and carbon tetrachloride; very soluble in ethyl alcohol; slightly soluble in water; MP (-97°C, -142.6°F); BP(-23.7°C, -10.7°F); DN(0.918 g/mL at 20°C); LSG (0.915); CP(40.8 J/K-mol gas at 25°C); HV (18.92 kJ/mol at 20°C); VD(1.78); VP(3,800 mmHg at 20°C).

**CHEMICAL PROPERTIES:** burns with a smoky flame; reacts with chemically-active metals such as potassium, powdered aluminum, zinc, and magnesium; reacts with water to form hydrochloric acid; FP (< 0°C, < 32°F); LFL/UFL (8.1%, 17.4%); AT (632°C, 1170°F); HF (-81.9 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable gas; NFPA rating Health 2, Flammability 4, Reactivity 0; dangerous fire hazard on exposure to heat, flame, or strong oxidizers; moderate explosion hazard when exposed to heat, flame or sparks; reacts explosively on contact with bromine trifluoride, bromine pentafluoride, magnesium, potassium, sodium, and, their alloys; explosive reaction with aluminum when heated to 152°C in a closed container; reacts exo-

thermically when mixed with aluminum chloride + ethylene and then explodes when pressurized to above 30 bar; ignites on contact with aluminum chloride or powdered aluminum; decomposition emits carbon monoxide, carbon dioxide, hydrogen chloride, and phosgene gas; use carbon dioxide, dry chemical, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (convulsions, nausea, vomiting, narcotic effects, dizziness, drowsiness, effects on the eye); contact (anesthesia through freezing of tissues on evaporation of methyl chloride).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water if frostbite has not occurred; seek medical attention immediately if frostbite has occurred; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 20,000ppm/2H; toxic effect: eye, central nervous system, gastrointestinal tract; oms-human lymphocyte 3 pph; sce-human lymphocyte 3 pph.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; irritation to mucous membranes and upper respiratory tract; narcotic effects; dizziness; nausea; vomiting; drowsiness; incoordination; confusion; abdominal pains; hiccoughs; visual disturbances; delirium; convulsions; slurred speech; staggering; liver and kidney damage; acute nephritis; anemia; coma; death.

**CHRONIC HEALTH RISKS:** damage to central nervous system; degenerative changes in the heart, liver, and kidneys; damage to the cardiovascular system; affects the bone marrow; hemorrhaging of the lungs and intestinal tract; anesthesia through freezing of tissues; reproductive disorders; may alter genetic material.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; ACGIH TLV STEL 100 ppm; OSHA PEL TWA 100 ppm; OSHA PEL CL 200 ppm; OSHA PEL 300 ppm/5M max peak/3H; IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; use fine water spray to disperse vapors; water jet should never be directed on liquid; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** disperse of in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; fireproof if in building; separate from incompatibles.

**REGULATORY INFORMATION:** CA2; F7, R2-R44; R3; R4; R5; U waste# (U045); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sfl; CW4; CW5; T799-5055; A1; A2; A5; CAL; DOT hazard class/division (2.1); labels (flammable gas).

**OTHER COMMENTS:** used as a local anesthetic; used in the manufacture of silicones, methyl cellulose, quaternary amines, and agricultural chemicals; also used as a food additive, dispersing agent, thickening agent, sizing agent, and an adhesive; use as a catalyst carrier at lower temperatures.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 13; 14; 19.

**METHYL CHLOROFORM (CH<sub>3</sub>CCl<sub>3</sub>, 133.40)****CAS/DOT IDENTIFICATION #:** 71-55-6/UN2831**SYNONYMS:** chloroethene, methyltrichloromethane, 1,1,1-trichloroethane, tri-ethane.

**PHYSICAL PROPERTIES :** colorless liquid; mild, chloroform-like odor; soluble in acetone, benzene, carbon tetrachloride, methanol, and ether; soluble in carbon disulfide; negligible solubility in water; absorbs some water; MP (-30°C, -22°F); BP (74°C, 165°F); DN (1.3376 g/mL at 20°C); LSG (1.34); ST (25.4 dynes/cm); VS (0.858 cP at 20°C); HV (8,012.7 gcal/gmole); VP (100 mmHg at 20°C, 127 mmHg at 25°C); OT (44 ppm).

**CHEMICAL PROPERTIES:** generally stable; reacts with strong oxidizers, alkalis, and active metals such as aluminum, zinc, magnesium powders, sodium, and potassium; reacts slowly with water to form hydrochloric acid; readily corrodes aluminum and aluminum alloys; FP (none); LFL/UFL (7.0%, 16.0%); AT (537°C, 998°F); HC (4,700 Btu/lb, 2600 cal/g, 110 x 10<sup>5</sup> J/kg).

**EXPLOSION and FIRE CONCERNS:** combustible liquid, but burns with difficulty ; NFPA rating Health 3, Flammability 1, Reactivity 1; no flash point in conventional closed tester; however, exposure to sources of high energy can cause vapors in containers to explode; reacts violently with aluminum oxide and heavy metals, dinitrogen tetraoxide, magnesium, aluminum, potassium, potassium-sodium alloys, sodium hydroxide, and both liquid and gaseous oxygen; exposure to open flames may produce hydrogen chloride and phosgene; decomposition emits toxic fumes of Cl; use dry chemical powder, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, loss of equilibrium, loss of consciousness); ingestion (dizziness, nausea, vomiting, gastrointestinal disturbances); contact (defatting of skin that may cause dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 920 ppm/70M; toxic effect: eye, central nervous system; inhalation-man TCLo 200 ppm/4H; toxic effect: central nervous system; inhalation man TCLo 350 ppm; toxic effect: central nervous system; inhalation-man LCLo 27 mg/m<sup>3</sup>/10M; oral-human TDLo 670 mg/kg; toxic effect: gastrointestinal tract; eye-man 450 ppm/8H.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; narcotic in high concentrations; cardiac arrest if massively inhaled; headache; nausea; vomiting; poor equilibrium; central nervous system depression; respiratory failure; weakness; exhaustion; death in high concentrations.

**CHRONIC HEALTH RISKS:** fatty degeneration of the liver; growth depression; ventricular arrhythmias.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 350 ppm; ACGIH TLV STEL 450 ppm; OSHA PEL TWA 350 PPM (1900 mg/m<sup>3</sup>); OSHA PEL STEL 450 ppm; NIOSH REL CL 350ppm/15M (1900 mg/m<sup>3</sup>/15M); IDLH 700 ppm.

**PERSONAL PROTECTION:** wear neoprene or polyvinyl alcohol (PVA) suit and aprons; wear neoprene safety footwear and neoprene or polyvinyl-alcohol-type gloves; wear chemical safety goggles, face shield and self contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb as much as possible with noncombustible materials such as vermiculite, dry earth, or sand; isolate and remove discharge material.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, package in epoxy-lined drums, and dispose of in a sanitary landfill; atomize in a high-temperature incinerator, equipped with afterburner or hydrochloric acid scrubber; encapsulate product residues by organic polyester resin or silicate fixation; store in a cool, dry location; storage should be in tightly closed containers separate from oxidizing materials, ammonia, and active metals; isolate from open flames and combustibles.

**REGULATORY INFORMATION:** CA2; R2-55; R3; R4; U waste #; (U226); Reportable Quantity (RQ): 1000 lbs. (454 kg); Sf1; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a solvent for fats, waxes, synthetic resins, tar and alkaloids; used as a solvent for adhesives, and extraction solvent, and as a solvent in textile dyeing; acts as both a vapor pressure depressant, and as a solvent and carrier for many of the active ingredients used in aerosols; used in vapor and metal degreasing

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

### METHYLCYCLOHEXANE (CH<sub>3</sub>C<sub>6</sub>H<sub>11</sub>, 98.19)

**CAS/DOT IDENTIFICATION #:** 108-87-2/UN2296

**SYNONYMS:** cyclohexylmethane, hexahydrotoluene, sextone b, toluene hexahydride.

**PHYSICAL PROPERTIES :** clear, colorless liquid; faint benzene-like odor; insoluble in water; soluble in alcohol, acetone, and benzene; MP (-126.3°C, -195°F); BP (101°C, 214°F); DN (0.769 g/mL at 20°C); LSG (0.77 at 20°C); ST (23.29 mN/m at 25°C); VS (0.679 mPa-s at 25°C); CP (184.8 J/K-mol liquid at 25°C); HV (35.36 kJ/mol at 25°C); VD (3.4); VP (37 mmHg at 20°C); OT (> 500 ppm).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts vigorously with strong oxidizers; FP (-3.9°C, 25°F); LFL/UFL (1.2%, 6.7%); AT (250°C, 482°F); HF (-190.1 kJ/mol liquid at 25°C); HC (-4.2571 x 10<sup>9</sup> J/kmol); H<sub>f</sub> (6.75 kJ/mol at 146.5K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; NFPA rating Health 2, Flammability 3, Reactivity 0; dangerous fire risk moderate explosion hazard when exposed to heat, flame or oxidizers; above flash point, vapor-air mixtures are explosive within flammable limits; flash back along vapor trail may occur; sealed containers may rupture when heated; sensitive to static discharge; contact with strong oxidizers may cause fire; carbon dioxide and carbon monoxide may form when heated to decomposition; use dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (lightheadedness, dizziness, drowsiness, nausea, narcosis and anesthesia in sub-lethal concentrations, loss of consciousness and death in high vapor concentrations); skin/eye contact (redness, itching, pain); ingestion (abdominal pain, nausea, vomiting, severe lung damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing,

provide respiratory support; if swallowed, do not induce vomiting; vomiting may occur spontaneously and it will be necessary to contact a physician immediately.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of mucous membranes and upper respiratory tract; lightheadedness; dizziness; drowsiness; nausea; abdominal pain; vomiting; irritation to skin and eyes, including redness and pain; severe lung damage; unconsciousness; death.

**CHRONIC HEALTH RISKS:** may cause skin effects; targets eyes, skin, respiratory system, and central nervous system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 400 ppm; OSHA PEL TWA 500 ppm (2000 mg/m<sup>3</sup>); NIOSH REL TWA 400 ppm (1600 mg/m<sup>3</sup>); IDLH 1200 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, proper gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield where splashing is possible; wear a full-facepiece self-contained breathing apparatus if the exposure limit is exceeded; eye wash fountains and quick-drench facilities should be provided in the immediate work area; use non-sparking tools and equipment.

**SPILL CLEAN-UP:** ventilate area of leak or spill; use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; collect liquid in an appropriate container or absorb with an inert material (e.g., dry sand, earth, vermiculite); flush remaining methylcyclohexane with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb with noncombustible materials such as dry earth, sand, or vermiculite, and place in a chemical waste container or in a secured sanitary landfill; whatever cannot be saved for recovery or recycling should be handled as a hazardous waste and sent to a RCRA approved incinerator or disposed of in a RCRA approved waste facility; store in a cool, dry location with adequate ventilation; keep away from any area where the fire hazard may be acute; outside storage is preferred; container should be bonded and grounded for transfers to avoid static sparks; separate from ignition sources and incompatibles; use non-sparking type tools and equipment, including explosion proof ventilation; protect against physical damage.

**REGULATORY INFORMATION:** T30-e10; T120-d10; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose ethers; also used in organic synthesis; useful as a laboratory reagent.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 14.

## **METHYLCYCLOHEXANOL (CH<sub>3</sub>C<sub>6</sub>H<sub>10</sub>OH, 114.21)**

**CAS/DOT IDENTIFICATION #:** 25639-42-3/UN2617

**SYNONYMS:** hexahydrocresol, hexahydromethylphenol.

**PHYSICAL PROPERTIES :** colorless or straw-colored liquid; slightly viscous; weak aromatic odor, similar to coconut oil; soluble in alcohol, ether, and esters; slightly soluble in water; MP (<-21°C, <-5.8°F); BP (155-180°C, 311-356°F); DN (0.924 g/mL at 15.5°C); LSG

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(0.92); VD (3.9); VP (2 mmHg at 86°F); OT (insufficient odor warning when the exposure limit value is exceeded).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react with oxidizing materials; FP (65-70°C, 149-158°F); LFL/UFL (unknown); AT (296°C, 565°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid when exposed to heat, flame or oxidizers; NFPA rating (NA); explosive vapor/air mixtures may be formed above 68°C; emits acrid fumes on heating; can react vigorously with oxidizing materials; use alcohol-resistant foam, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, headache, antipsychotic effects, kidney damage, injury to the liver, irritates upper respiratory system); skin contact (dry skin, redness, dermatitis); eye contact (redness).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if swallowed, rinse mouth and induce vomiting; refer for immediate medical attention.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 500 ppm; toxic effect: central nervous system, liver, kidney.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory tract; headache; cough; dry skin, including redness; narcotic effects; antipsychotic effects; unspecified liver and kidney effects.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact with skin may cause dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (234 mg/m<sup>3</sup>); OSHA PEL TWA 100 ppm (470 mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (235 mg/m<sup>3</sup>); IDLH 500 ppm..

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield where splashing is possible; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear positive pressure self-contained breathing apparatus in high concentrations; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** collect leaking and spilled liquid in sealable containers as far as possible; absorb remaining liquid with an inert material (e.g., dry sand, earth, vermiculite), and place in a chemical waste container; use water spray to cool and reduce vapors, and dilute spills to form nonflammable mixtures; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent and place in a secured, sanitary landfill; whatever cannot be saved for recovery or recycling can also be sent to a RCRA approved incinerator or disposed of in a RCRA approved waste facility; store in a cool, dry location; keep away from any area where the fire hazard may be acute; separate from strong oxidizing materials.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose esters, ethers and lacquers; applications as an anti-oxidant for lubricants and as a blending agent for textile soaps and detergents.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

### **o-METHYLCYCLOHEXANONE (C<sub>7</sub>H<sub>12</sub>O, 112.19)**

**CAS/DOT IDENTIFICATION #:** 583-60-8/UN2297

**SYNONYMS:** 2-methyl-1-cyclohexanone, 1-methylcyclohexan-2-one, 2-methylcyclohexanone, alpha-methylcyclohexanone, sexton b.

**PHYSICAL PROPERTIES:** water-white to pale yellow liquid; weak, peppermint-like odor; a mixture of cyclic ketones; physical properties, miscibility, and tolerance for non-solvent and solvent action most closely resembles that of cyclohexanone; soluble in alcohol and ether; not soluble in water; MP (-14°C, 7°F); BP (165°C, 329°F); DN (0.9250 g/mL liquid at 20°C); LSG (0.93); VD (3.86); REL DN vapor/air mixture (1.004 at 20°C); VP (1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with strong oxidizers (such as chlorine, bromine, and fluorine); FP (48°C, 118°F); LFL/UFL (unknown); AT (unknown); HC (data not found in literature); IR (1.4440 at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid, NFPA rating Health (not rated), Flammability 2, Reactivity 0; moderate fire risk; explosive vapor/air mixtures may be formed above 48°C; violent reaction with strong oxidizers, such as chlorine, bromine and fluorine; upon heating, toxic fumes are produced; use dry chemical, carbon dioxide, or foam extinguishers for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sore throat, drowsiness, headache, dizziness, irritates eyes and respiratory tract); contact (strongly irritates and damages eyes, causes a rash or burning sensation, may cause thickening and cracking of skin); skin absorption (nervous system disturbances); ingestion (may cause burning sensation).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; provide rescue breathing if breathing has stopped; rinse mouth, and give plenty of water to drink, and induce vomiting; seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; sore throat; headache; dizziness; light-headedness; drowsiness; nervous system disturbances/central nervous system depression; may cause a rash or burning feeling.

**CHRONIC HEALTH RISKS:** repeated exposure may affect the liver, kidneys, and lungs; long-term contact may cause thickening and cracking of skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (229 mg/m<sup>3</sup>); ACGIH TLV STEL 75 ppm (344 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 100 ppm (460 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 50 ppm (230 mg/m<sup>3</sup>); NIOSH REL STEL 75 ppm (345 mg/m<sup>3</sup>)(skin); IDLH 600 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, rubber gloves, lab-coat, apron or coveralls; use splash-proof chemical safety goggles and face

shield when working with liquid; enclose operations and/or provide local exhaust ventilation at the site of chemical release; use explosion-proof electrical equipment; appropriate respirators are needed in areas where exposures are above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; a vapor suppressing foam may be used to reduce vapors; absorb liquids with dry earth, sand or vermiculite, and deposit in sealed containers; flush remaining spill with large amounts of water but not into confined spaces such as sewers because of possibility of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** collect spilled liquid in sealable containers or absorb in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry area; use only with adequate ventilation; fireproof if in building; must be stored to avoid contact with strong oxidizers; keep away from sources of ignition such as smoking and open flames.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (not found in literature); label (not found in literature).

**OTHER COMMENTS:** use as a solvent in making varnish and plastics and in the leather industry; utilized as a rust remover.

**KEY REFERENCES:** 4; 5; 6; 7; 14; 15.

### METHYLENE CHLORIDE (CH<sub>2</sub>Cl<sub>2</sub>, 84.93)

**CAS/DOT IDENTIFICATION #:** 75-09-2/UN1593

**SYNONYMS:** dichloromethane, methane, dichloride, methylene bichloride, methylene dichloride.

**PHYSICAL PROPERTIES :** colorless liquid; sweet, chloroform-like odor; miscible with alcohol, acetone, chloroform, ether, carbon tetrachloride, and dimethylformamide; very slightly soluble in water; partially miscible with less polar organic solvents; MP (-97°C, -142°F); BP (40°C, 104°F); DN (1.326 g/mL at 20°C); LSG (1.33); ST (26.52 dynes/cm); VS (0.430 cP at 20°C); CP (101.1 J/K-gmol liquid at 25°C); HV (28.06 kJ/gmole); VD (2.93); VP (350 mmHg at 20°C, 1250 mmHg at 55°C); OT(205-307 ppm).

**CHEMICAL PROPERTIES:** relatively stable in the absence of moisture at ordinary temperatures; will not polymerize; reacts with active metals such as aluminum, magnesium powders, potassium, and sodium; reacts with strong oxidizers and concentrated nitric acid; FP (none); LFL/UFL(13%, 23%); AT (556°C, 1033°F); HC (-513.9 kJ/mol); HF (124.1 kJ/gmol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; flammable in the range of 12-19% in air but ignition is difficult; NFPA rating Health 2, Flammability 1, Reactivity 0; forms flammable vapor-air mixtures; forms explosive mixtures with an atmosphere having a high oxygen content; explosive in liquid oxygen, dinitrogen tetroxide, potassium, sodium, and sodium-potassium alloys; very explosive in vapor form when exposed to heat or flame; violent reactions with lithium, sodium-potassium alloys, aluminum, and potassium-tert-butoxide; no flash point in conventional closed tester, but may be explosive in confined spaces; hazardous combustion by-products include carbon monoxide, carbon dioxide, hydrogen chloride gas, and phosgene gas; use water spray, dry chemical, carbon dioxide, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (anesthetic effects, nausea, and drunkenness); contact (skin irritation, irritation of eyes and nose).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin promptly with large amounts of soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TClO 500ppm/1Y; toxic effect: central nervous system, cardiovascular system; inhalation-human TClO 500ppm/8H; toxic effect: central nervous system; oral-human LDLo 357 mg/kg; toxic effect: central nervous system; oral-human LDLo 357 mg/kg; toxic effect: central nervous system, peripheral nervous system; dni-human fibroblast 5000 ppm/1H; EPA Cancer Risk Level (1 in a million excess lifetime risk):  $2 \times 10^{-3}$  mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory tract; destructive to tissues of mucous membranes; nausea; dizziness; headache; weakness; fatigue; numbness or tingling of limbs; lightheadedness; reduces oxygen carrying capacity of blood; loss of consciousness.

**CHRONIC HEALTH RISKS:** change in heart rate; paresthesia; altered sleep time; somnolence; convulsions; euphoria; experimental teratogen; experimental reproductive effects; confirmed carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50ppm; OSHA PEL TWA 25 ppm; OSHA PEL STEL 125 ppm; NIOSH REL reduce to lowest feasible level; IDLH 2300ppm.

**PERSONAL PROTECTION:** wear full protective clothing; rubber clothing may be used; wear chemical protective boots and chemical-resistant gloves; wear safety goggles and a self-contained breathing apparatus approved for organic vapors and fumes; use only in chemical fume hood.

**SPILL CLEAN-UP:** absorb as much as possible with materials such as dry earth or sand; flush remaining methylene chloride with large amounts of water and disperse, but not into confined spaces such as sewers because of danger of explosion.

**DISPOSAL AND STORAGE METHODS:** absorb residue on dry sand, earth, or ashes, and allow to evaporate into the atmosphere; may be used as fill or may be dumped into a landfill; store in a cool, dry location away from heat and open flame; isolate from chemically active metals; storage should be in tightly closed containers; outside storage is preferred.

**REGULATORY INFORMATION** CA2; S1; S10; F2; R2-46; R3; R4; R5; R7; R8; R9; U waste #(U080); Reportable Quantity (RQ): 1000 lbs (454 kg); Sfl; CW4; CW5; T120-a; A1; A2; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as a solvent in paint removers and as a solvent for cellulose acetate; vapor degreasing solvent for metals and plastics; major use as a solvent and cleaning agent in the chemical processing industry; used in the pharmaceutical industry as a solvent in the production of antibiotics, steroids, and vitamins; chemical intermediate for bromochloromethane.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 13; 14; 19.

**METHYL FORMATE (HCOOCH<sub>3</sub>, 60.06)**

**CAS/DOT IDENTIFICATION #:** 107-31-3/UN1243

**SYNONYMS:** formic acid methyl ester, methanoic acid methyl ester, methyl ester of formic acid, methyl methanoate.

**PHYSICAL PROPERTIES :** colorless liquid; pleasant odor; a gas above 89°F; solidifies at about 100°C (212°F); moderately soluble in water, methyl alcohol and ether; MP (-100°C, -148°F); BP (32°C, 89.6°F); DN (0.98149 g/mL at 15°C, 0.975 g/mL at 20°C); LSG (0.98); ST (24.36 mN/m at 25°C); CP (119.1 J/K-mol liquid at 25°C); HV (28.35 kJ/mol at 25°C); VD (2.07); VP (476 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts slowly with water to form methanol and formic acid; saponified by water or alkaline solutions; can react vigorously with oxidizing materials; FP (-19°C, -2°F); LFL/UFL (5%, 23%); AT (456°C, 853°F); HF (-386.1 kJ/mol liquid at 25°C); HC (-0.8924 x 10<sup>9</sup> J/kmol).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 4, Reactivity 0; vapor is heavier than air, mixes well with air, and easily forms explosive mixtures; flashback along vapor trail may occur; very dangerous fire risk when exposed to heat or flame; reacts vigorously with oxidants; forms an explosive product when it reacts with methanol and sodium methoxide; exposures to high concentrations have resulted in industrial fatalities; combustion may produce irritants and toxic gases; use water spray, alcohol-resistant foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, dizziness, headache, dullness, labored breathing, shortness of breath, irritates nasal passages, irritates conjunctiva, optic neuritis, narcosis, retching, death from pulmonary irritation); skin/eye contact (redness, irritation, pain); ingestion (vomiting, loss of consciousness, other symptoms parallel those of inhalation).

**FIRST AID:** rinse eyes with plenty of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if swallowed, rinse mouth and give a slurry of activated charcoal in water to drink; induce vomiting and get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; nasal irritation; conjunctivitis; cough; dizziness; headache; chest oppression; vomiting; difficult breathing; visual disturbance; central nervous system depression; pulmonary edema and narcotic effects have been reported in animals.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm (246 mg/m<sup>3</sup>); ACGIH TLV STEL 150 ppm; OSHA PEL TWA 100 ppm (250 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (250mg/m<sup>3</sup>); NIOSH REL STEL 150 ppm (375 mg/m<sup>3</sup>); IDLH 4500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield where splashing is possible; a closed system of local exhaust ventilation is recommended to control emissions of the contaminant at its source and to prevent dispersion of it into the general work area; use explosion-proof electrical equipment and lighting; compressed air should not be used for filling, discharging, or handling; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); in high vapor concentrations, wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** collect leaking liquid in sealable containers; absorb remaining liquid in sand or other inert absorbent, and place in a chemical waste container; use water spray to cool and reduce vapors, and dilute spills to form nonflammable mixtures; do not wash away into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible with an inert material (e.g., dry sand, earth, vermiculite), and place in a sanitary landfill; store in a cool, dry, well-ventilated location; outside storage is preferred; keep away from any area where the fire hazard may be acute; separate from strong oxidants, alkalies, and moisture.

**REGULATORY INFORMATION:** F7; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose acetate; useful in organic synthesis; has also been used as a fumigant and larvicide for tobacco and food crops; fire hazard is avoided by use with carbon dioxide.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 14.

## METHYL HYDRAZINE (CH<sub>3</sub>NHNH<sub>2</sub>, 46.09)

**CAS/DOT IDENTIFICATION #:** 60-34-4/UN1244

**SYNONYMS:** hydrazomethane, 1-methyl hydrazine, mmh, monomethylhydrazine.

**PHYSICAL PROPERTIES :** clear, colorless liquid; hygroscopic (able to adsorb moisture from air); ammonia-like odor; slightly soluble in water; miscible with water, hydrazines, and monohydric alcohols; soluble in hydrocarbons, ether, and alcohols; MP (-52.4°C, -62.3°F); BP (87.5°C, 189.5°F); DN (0.874 g/mL at 25°C); LSG (0.87); CP (134.9 J/K-mol liquid at 25°C); HV (40.37 kJ/mol at 25°C); VD (1.6); REL DN vapor/air mixture (1.03 at 20°C); VP (38 mmHg at 20°C, 206 mmHg at 55°C); OT (2.1 ppm).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; mildly alkaline base; strong reducing agent; reacts with oxidizing agents, oxygen, and peroxides; FP (-8.3°C, 17.1°F); LFL/UFL (2.5%, 97±2%); AT (194°C, 381°F); HF (54.0 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; very dangerous fire hazard; NFPA rating Health 3, Flammability 3, Reactivity 2; explosive in the form of vapor; vapor mixes well with air, easily forming explosive mixtures; flashback along vapor trail may occur; closed containers may rupture violently when heated; may spontaneously ignite on contact with air and porous materials (e.g., wood, earth, asbestos or cloth); risk of fire and explosion on contact with oxidants and metal oxides; violent reaction with oxygen, strong oxidizers (e.g., dinitrogen tetroxide and hydrogen peroxide), and peroxides, sometimes resulting in auto-ignition; reacts violently with strong acids; decomposes on heating or on burning producing carbon dioxide, carbon monoxide, and toxic fumes of oxides of nitrogen; use powder, alcohol foam, carbon dioxide and large amounts of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (bluish discoloration of skin, cough, dizziness, headache, labored breathing, burning sensation, convulsions, nausea, vomiting); skin contact (redness, pain, blisters, may cause allergic skin reactions); skin absorption (tremors, convulsions, muscular incoordination, skin sensitization); eye contact (severe deep burns, redness, pain); ingestion (abdominal cramps, nausea, vomiting, diarrhea, burning sensation, weakness).

**FIRST AID:** wash eyes immediately with large amounts of water; rinse affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and provide oxygen; provide artificial respiration if indicated; in case of ingestion, rinse mouth and give plenty of water to drink.

**HUMAN TOXICITY DATA:** DNA damage-human fibroblast 116 pmol; EPA Cancer Risk Level: non-threshold category, 1/ED<sub>10</sub> (4.1 mg/kg/day); probably human carcinogen, group B2.

**ACUTE HEALTH RISKS:** corrosive to skin, eyes and upper respiratory tract; destructive to tissues of mucous membranes; may cause lung edema; blue lips or fingernails; blue skin; cough; dizziness; headache; labored breathing; burning sensation; nausea; vomiting; diarrhea; abdominal cramps; weakness; ataxia; tremors; anoxia; convulsions; edema of the larynx and bronchi; chemical pneumonitis; may cause effects on central nervous system, liver and blood; exposure at high concentrations may result in death.

**CHRONIC HEALTH RISKS:** may have effects on the liver and blood, resulting in formation of methemoglobin; impairment of kidneys; possible carcinogenic to humans.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 0.2 ppm (0.38 mg/m<sup>3</sup>), suspected human carcinogen; OSHA PEL CL 0.2 ppm (0.35 mg/m<sup>3</sup>)(skin); NIOSH REL CL 0.4 ppm (0.08 mg/m<sup>3</sup>/2H); IDLH 20 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use explosion-proof electrical equipment and lighting; in high vapor concentrations use self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill use water spray to cool and disperse vapors; collect leaking liquid in sealable containers; absorb remaining liquid with noncombustible materials (e.g., dry earth, sand, vermiculite), and remove to a safe place; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; outside storage is preferred; keep in tightly closed containers; keep under inert gas; separate from acids; oxidizing materials, metal oxides, halogens, and porous materials.

**REGULATORY INFORMATION:** CA2; R4; R7; R8; P waste # (P068); Reportable Quantity (RQ): 10 lbs. (4.54 kg); Sf1; Sf2; Sf3; A1; A5; CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid, corrosive).

**OTHER COMMENTS:** used as high energy fuel in military applications, such as rocket fuel and missile propellant; also used as fuel for small electrical power generating units; useful as an intermediate in chemical syntheses.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 14; 19.

**METHYL IODIDE (CH<sub>3</sub>I, 141.94)**

**CAS/DOT IDENTIFICATION #:** 74-88-4/UN2644

**SYNONYMS:** halon10001, iodomethane, monoiodomethane

**PHYSICAL PROPERTIES :** colorless, transparent liquid; turns yellow, red, or brown on exposure to light and moisture; pungent, ether-like odor; miscible with alcohol and ether; soluble in water at 15°C; MP (-66.5°C, -87.7°F); BP (42.5°C, 108.5°F); DN (2.279 g/mL at 20°C); LSG (2.28); ST (30.34 mN/m at 25°C); VS (0.469 mPa-s at 25°C); CP (126.0 J/K-mol liquid at 25°C); HV (27.97 kJ/mol at 25°C); VD (4.89); VP (400 mmHg at 25.3°C).

**CHEMICAL PROPERTIES:** noncombustible liquid; reacts with strong oxidizers; decomposes at 518°F; FP (none at 300°C); HF (-12.3 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** NFPA rating (not available); reacts violently with oxygen at 300°C; violent reaction with sodium; reacts explosively with trialkylphosphines and silver chlorite; decomposition emits toxic fumes of I; use water spray, carbon dioxide, dry chemical powder, or appropriate foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, wheezing, burning sensation, shortness of breath); skin absorption (nausea, vomiting, vertigo); contact (skin blistering).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide respiratory support and oxygen.

**HUMAN TOXICITY DATA:** skin-human 1g/10M mild erythema and slight edema.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; destructive to tissues of the mucous membranes; nausea; vomiting; vertigo; slurred speech; drowsiness; ataxia; weakness; pulmonary edema; blistering of skin.

**CHRONIC HEALTH RISKS:** suspected carcinogen; may alter genetic material; reproductive disorders; dermatitis; anesthetic effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (skin); OSHA PEL TWA 5 ppm (28 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10 mg/m<sup>3</sup> reduce to lowest level; IDLH 100 ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; use fine water spray to disperse vapors; water jet should never be directed on liquid; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; fireproof if in building; separate from incompatibles.

**REGULATORY INFORMATION:** CA2; R2-48; R3; R4; R5; U waste# (U138); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sfl; Sf3; A1; A5; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a methylating agent; used in testing for pyridine; used in microscopy; light sensitive etching agent for electronic circuits; use as a component in fire extinguishers.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 13; 14; 19.

**METHYL ISOAMYL KETONE (CH<sub>3</sub>COC<sub>2</sub>H<sub>4</sub>CH(CH<sub>3</sub>)<sub>2</sub>, 114.21)**

**CAS/DOT IDENTIFICATION #:** 110-12-3/UN2302

**SYNONYMS:** isoamyl methyl ketone, isopentyl methyl ketone, 2-methyl-5-hexanone, 5-methyl-2-hexanone, miak.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mild, fruity odor; miscible with most organic solvents; slightly soluble in water; MP (-73.9°C, -101°F); BP (144°C, 291°F); DN (0.8132 g/mL at 20°C); LSG (0.81); VD (3.9); VP (4.5 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; may be moderately degraded by photolysis when released into air; may evaporate to a moderate extent when released into water; FP (36°C, 97°F); LFL/UFL (1.0%, 8.2%); AT (191°C, 376°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; NFPA rating Health 2, Flammability 3, Reactivity 0; flashback along vapor trail may occur; sensitive to static discharge; vapor-air mixtures are explosive within flammable limits above the flash point; moderate fire hazard when exposed to oxidizers; carbon dioxide and carbon monoxide may form when heated to decomposition; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates mucous membranes, coughing, shortness of breath, headache, narcosis, affects central nervous system); contact (skin irritation, defatting of skin, dermatitis, severe eye pain and irritation, kidney and liver damage); ingestion (irritates gastrointestinal tract, nausea, vomiting, diarrhea).

**FIRST AID:** flush eyes immediately with plenty of water; flush skin immediately with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if ingested, induce vomiting immediately and get medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to respiratory tract; irritation to tissues of mucous membranes coughing; shortness of breath; narcotic effects; nausea; vomiting; diarrhea; headache; irritation to skin, including redness, itching, and pain; severe eye pain and irritation; coma.

**CHRONIC HEALTH RISKS:** repeated or prolonged skin contact may defat the skin; dermatitis; kidney and liver damage are reported in animals; pre-existing skin or eye problems or impaired liver, kidney, or respiratory function may be further aggravated by the effects of this substance.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; OSHA PEL TWA 100ppm (475mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (240 mg/m<sup>3</sup>); IDLH (NA).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or full face shield where dusting or splashing is possible; wear self-contained breathing apparatus with full facepiece operated in positive pressure mode; use non-sparking type tools and equipment, including explosion proof ventilation; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and reduce vapors, and dilute spills to form nonflammable mixtures; collect liquid in an appropriate container or absorb with noncombustible materials (e.g., dry earth, sand, clay), and place in a chemical

waste container; flush remaining liquid with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be handled as a hazardous waste and sent to a RCRA approved incinerator or disposed of in a RCRA approved waste facility; store in a cool, dry location with adequate ventilation; outside storage is preferred; containers should be bonded and grounded for transfers to avoid static sparks; separate from incompatibles and keep away from any area where the fire hazard may be acute; storage and use areas should be No Smoking Areas.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for nitrocellulose, cellulose acetate butyrate, vinyl copolymers, and acrylics; use as a laboratory reagent.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 14.

### **METHYL ISOBUTYL CARBINOL (C<sub>6</sub>H<sub>14</sub>O, 102.20)**

**CAS/DOT IDENTIFICATION #:** 108-11-2/UN2053

**SYNONYMS:** 4-dimethyl butan-2-ol, isobutylmethylcarbinol, methyl amyl alcohol, 2-methyl-4-pentanol, 4-methyl-2-pentanol, mibc.

**PHYSICAL PROPERTIES:** clear, colorless liquid; mild odor; soluble in alcohol and ether; slightly soluble in water; miscible with most common organic solvents; MP (-90°C, -130°F); BP (132°C, 270°F at 760 mmHg); DN (0.8079 g/mL liquid at 20°C); LSG (0.81 at 20°C); CP (273.0 J/K-mol liquid at 25°C); HV (58.7 kJ/mol at 25°C); VD (3.53); VP (2.8 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; sets to a glass below -90°C; reacts with strong oxidants; FP (41°C, 106°F); LFL/UFL (1.0%, 5.5%); AT (data not found in literature); HC (data not found in literature); HF (-394.7 kJ/mol liquid at 25°C); IR (1.4089 at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable and combustible liquid; moderate explosion hazard upon exposure to heat or flame; explosive vapor/air mixtures may be formed above 41°C; vapor is heavier than air and may travel along the ground; distant ignition possible; NFPA rating Health 2, Flammability 2, Reactivity 0; can react vigorously with oxidizing materials; heating to decomposition emits carbon monoxide and carbon dioxide; use alcohol-resistant foam, water spray, powder or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, difficult breathing, anesthesia, cough, sore throat, unconsciousness, irritates eyes, skin and respiratory tract); contact (irritates eyes, irritates skin, causes cracking of skin).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; if breathing has stopped provide artificial respiration; in case of ingestion, rinse mouth and seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

## 752 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; cough; sore throat; headache; drowsiness; anesthetic effects; dry skin; could cause lowering of consciousness.

**CHRONIC HEALTH RISKS:** liquid may cause defatting of skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm (104 mg/m<sup>3</sup>); ACGIH TLV STEL 40 ppm (167 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 25 ppm (100 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 25 ppm (100 mg/m<sup>3</sup>); NIOSH REL STEL 40 ppm (165 mg/m<sup>3</sup>)(skin); IDLH 400 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; above 41°C (106°F), enclose operations and/or use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; collect spilled liquid in sealable containers or absorb with materials (e.g., dry earth, sand or vermiculite), and place in chemical waste containers; flush remaining material with large amounts of water but not into confined spaces such as sewers because of possibility of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be mixed with additional flammable solvent and burned in an incinerator equipped with appropriate effluent gas cleaning device; store in a cool, dry location; maintain adequate ventilation; fireproof if in building; separate from strong oxidants.

**REGULATORY INFORMATION:** Al; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** used as a solvent for dyestuffs, gums, resins, waxes, oils, nitrocellulose, and ethylcellulose; utilized in the manufacture of solvents, lacquers, plasticizers, and lubricant additives; useful in organic synthesis, in froth flotation, and in the preparation of brake fluids.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 11; 14.

### METHYL ISOCYANATE (C<sub>2</sub>H<sub>3</sub>NO, 57.06)

**CAS/DOT IDENTIFICATION #:** 624-83-9/UN2480

**SYNONYMS:** isocyanate methyl methane, isocyanic acid methyl ester, MIC, RCRA waste number P064.

**PHYSICAL PROPERTIES :** colorless liquid; sharp odor; very soluble in water; MP (-80°C, -112°F); BP (39°C, 102°F); DN (0.9599 g/mL at 20°C); LSG (0.96); VS (0.127 cP at 20°C); VD (2.0); VP (348 mmHg at 20°C, 1399 mmHg at 55°C); OT(2.1 ppm).

**CHEMICAL PROPERTIES:** may polymerize easily; polymerization may be hazardous; usually contains inhibitors to prevent polymerization; uninhibited monomer vapor may polymerize in vents and confined spaces; reacts with strong oxidizing agents, alcohols, acids, amines, strong bases, iron, tin and copper; reacts vigorously with water; FP (-7°C, -19°F); LFL/UFL(5.3%, 26%); AT (534°C, 994°F); HF (-92.0 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; very dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 3; reacts exothermically with water, causing a runaway reaction; vapors are heavier than air and flash back on exposure to a source of ignition; closed containers may rupture violently on heating; may polymerize explosively; incompatible with heat, flame, or oxidizers; hazardous combustion products include oxides of nitrogen, hydrogen cyanide, carbon monoxide, and carbon dioxide; use water spray, foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (spasm, inflammation and edema of the larynx and bronchi, chemical pneumonitis, pulmonary edema, conjunctiva irritation, and olfactory changes); skin absorption (blindness, lung damage, emphysema, gynecological effects); contact (mucous membrane irritant, respiratory sensitizer, skin damage).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin promptly with large amounts of water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 2 ppm; toxic effect: nose, eye, pulmonary system; EPA Cancer Risk Level: not classifiable.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory tract; extremely destructive to tissues of mucous membranes; coughing; wheezing; bronchitis; bronchial pneumonia; breathing difficulty; labored breath; laryngitis; headaches; cyanosis; pulmonary secretions; chest pain; nausea; vomiting; dizziness; gastritis; sweating; chills; fever; liver and kidney damage; permanent fibrosis; blindness.

**CHRONIC HEALTH RISKS:** spontaneous abortions; increased number of stillbirths; pelvic inflammatory disease; excessive menstrual bleeding; suppression of lactation; leukorrhea.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.02 ppm (skin); OSHA PEL TWA 0.02 ppm (0.05mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.02 ppm (0.05mg/m<sup>3</sup>) (skin); IDLH 3ppm.

**PERSONAL PROTECTION:** wear rubber apron, sleeves, and other protective clothing; wear long chemical-resistant gauntlet gloves; wear chemical safety goggles and protective face shield; wear positive pressure self-contained apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; store in a cool, dry place away from heat, sunlight, and oxidizing materials; storage should be in a tightly closed stainless steel container; store under nitrogen; isolate from acids, alkalis, amines, water, iron, tin, and copper; outside storage is preferred.

**REGULATORY INFORMATION** CA2; R4; P waste # (P064); Reportable Quantity (RQ): 10lbs. (4.54kg); Sf1; Sf2; Sf3; A1; A5; CAL; DOT hazard class/division (3); labels (poison, flammable liquid).

**OTHER COMMENTS:** used in organic synthesis; used in the manufacture of carbamate insecticides and herbicides; an industrial accident during the manufacture of carbaryl in Bhopal, India in December 1984 resulted in the release of an unknown amount of methyl isocyanate into the atmosphere, leading to the deaths of over two thousand people.

**KEY REFERENCES:** 1; 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 13; 14; 19.

**METHYL MERCAPTAN (CH<sub>3</sub>SH, 48.11)****CAS/DOT IDENTIFICATION #:** 74-93-1/UN1064**SYNONYMS:** mercaptomethane, methanethiol, methyl sulfhydrate, thiomethanol, thiomethyl alcohol.**PHYSICAL PROPERTIES :** colorless gas; water-white liquid when below its boiling point; odor like garlic or rotten cabbage; soluble in alcohol, ether and petroleum naphtha; slightly soluble in water; forms an azeotrope with isobutane (14.9% methanethiol); MP (-123°C, -189°F); BP (6°C, 43°F); DN (0.8665 g/mL liquid at 20°C); LSG (0.90 at 32°F); CP (0.773-17.47 cal/deg/mole solid at 14.97-146.57K, 21.27-21.13 cal/deg/mol liquid at 154.16-271.06K); VD (1.7); VP (1292 mmHg at 20°C).**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts vigorously with strong oxidizing agents and mercury (II) oxide; FP (-18°C, -0.4°F (liq)); LFL/UFL (3.9%, 21.8%); AT (NA).**EXPLOSION and FIRE CONCERNS:** extremely flammable gas; NFPA rating Health 2, Flammability 4, Reactivity 0; very dangerous fire hazard; explosive in vapor form when exposed to heat or flame; gas/air mixtures are explosive; flashback along vapor trail may occur; distant ignition possible; reacts violently with strong oxidants; can react dangerously with mercury (II) oxide; reacts with water, steam or acids to form flammable and toxic gas (e.g., hydrogen sulfide); decomposes on heating and on burning producing toxic oxides of sulfur; use dry chemical, alcohol foam or carbon dioxide for firefighting purposes.**HEALTH SYMPTOMS:** inhalation (cough, headache, nausea, sore throat, shortness of breath, lung edema, respiratory paralysis, convulsions unconsciousness); skin contact (frostbite, redness, pain); eye contact (redness, pain); ingestion (symptoms parallel those of inhalation).**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; on frostbite, rinse affected areas of skin with plenty of water; if breathing is difficult, remove to fresh air and provide oxygen; if not breathing, give artificial respiration.**HUMAN TOXICITY DATA:** no toxicity data reported in humans.**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; cough; headache; sore throat; shortness of breath; cyanosis; narcosis; nausea; pulmonary edema; pulmonary irritation; effects on central nervous system; respiratory failure; rapid evaporation of the liquid may cause frostbite; death in high concentrations.**CHRONIC HEALTH RISKS:** no information found.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (0.98mg/m<sup>3</sup>); OSHA PEL CL 10 ppm (20 mg/m<sup>3</sup>); NIOSH REL CL 0.5ppm/15M (1 mg/m<sup>3</sup>/15M); IDLH 150 ppm.**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles or eye protection in combination with breathing protection; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use explosion-proof electrical equipment and lighting; positive pressure self-contained breathing apparatus should be worn in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.**SPILL CLEAN-UP:** stop or control leak if possible; use water spray to cool and reduce vapors; dilute spills to form nonflammable mixtures and isolate for proper disposal.

**DISPOSAL AND STORAGE METHODS:** turn leaking cylinder with the leak up to prevent escape of gas in liquid state; store in a cool, dry location; maintain adequate ventilation; keep away from any area where the fire hazard may be acute; separate from strong oxidants and acids.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 100 lbs. (45.4kg); Sf1; Sf2; Sf3; CW1; CW2; A1; A5; CAL; DOT hazard/class division (2.3); labels (poison gas, flammable gas).

**OTHER COMMENTS:** used as an intermediate in the manufacture of jet fuels, fungicides, pesticides, and plastics; has been used in the synthesis of methionine; also useful as a catalyst.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 14.

### **METHYL METHACRYLATE (C<sub>5</sub>H<sub>8</sub>O<sub>2</sub>, 100.13)**

**CAS/DOT IDENTIFICATION #:** 80-62-6/UN1247

**SYNONYMS:** methacrylate monomer, methyl ester of methacrylic acid, methyl-2-methyl-2-propenoate, 2-methyl-2-propenoic acid methyl ester.

**PHYSICAL PROPERTIES :** colorless liquid; acrid, fruity odor; soluble in acetone; very slightly soluble in water; MP (-48°C, -55°F); BP (100°C, 213°F); DN (0.936 g/mL at 20°C); LSG (0.94); HV (40.7 kJ/mol at 25°C); VD (3.45); VP (29 mmHg at 20°C, 40mmHg at 25.5°C).

**CHEMICAL PROPERTIES:** may polymerize if exposed to heat, oxidizers, or ultraviolet light; usually contains an inhibitor such as hydroquinone to prevent polymerization; reacts with strong acids, alkalis, nitrates, oxidizers, peroxides and moisture; FP (10°C, 50°F); LFL/UFL(1.7%, 8.2%); AT (435°C, 815°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; very dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 2; monomer may undergo explosive polymerization; explosive in vapor form if subjected to heat or flame; vapors may travel to an ignition source and flash back; explodes on evaporation at 60°C; liquid floats on water and may travel to an ignition source and spread fire; reacts violently with dibenzoyl peroxide, di-tert-butyl peroxide, propionaldehyde, and azoisobutyronitrile; ignites on contact with benzoyl peroxide; incompatible with strong acids, alkalis, oxidizers, peroxides, high temperature, and sunlight; hazardous combustion products include carbon monoxide and carbon dioxide; use carbon dioxide, dry chemical, foam, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sleep effects, excitement, anorexia, decrease in blood pressure, nausea, vomiting, headache, dizziness, unconsciousness); contact (burning sensation, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin promptly with large amounts of water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLO 125 ppm; toxic effect: central nervous system; inhalation-human TCLO 60mg/m<sup>3</sup>; toxic effect: central nervous system, cardiovascular system.

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**ACUTE HEALTH RISKS:** irritation to eyes, skin and upper respiratory tract; destructive to tissues of the mucous membranes; inflammation and edema of larynx and bronchi; coughing; wheezing; laryngitis; labored breath; headache; dizziness; nausea; vomiting; confusion; unconsciousness.

**CHRONIC HEALTH RISKS:** cardiovascular disorders; lesions of the kidney and liver; effects on the nasal cavity; sleeping disturbances; dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; OSHA PEL TWA 100 ppm (410mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (410mg/m<sup>3</sup>); IDLH 1000ppm.

**PERSONAL PROTECTION:** wear full protective clothing including aprons, boots, sleeves, etc.; wear long chemical resistant gauntlet gloves; wear splash-proof safety goggles; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb in noncombustible materials such as dry earth or sand; flush remaining methyl methacrylate with large amounts of water but not into confined spaces such as sewers because of danger of explosive polymerization; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; store in a cool, dry place separate from oxidizing materials, peroxides, or other initiators; keep containers tightly closed; keep away from heat, sparks, and open flame.

**REGULATORY INFORMATION** CA2; R3; R4; R5; U waste # (U162); Reportable Quantity (RQ): 1000lbs (454 kg); Sf1; Sf3; CW1; CW2; T120-a; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** use as a monomer in the manufacture of polymethacrylate resins and plastics; used as a component of bone cement and molding/extrusion powder; used in the manufacture of plumbing and bathroom fixtures, lighting fixtures, skylights, and advertising signs.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 12; 13; 14; 19.

### alpha-METHYL STYRENE (C<sub>6</sub>H<sub>5</sub>C(CH<sub>3</sub>)=CH<sub>2</sub>, 118.19)

**CAS/DOT IDENTIFICATION #:** 98-83-9/UN2303

**SYNONYMS:** ams, isopropenyl benzene, 1-methyl-1-phenylethylene, 2-phenylpropene, 2-phenylpropylene.

**PHYSICAL PROPERTIES :** colorless liquid; has a characteristic odor; insoluble in water; miscible in alcohol and ether; MP (-23°C, -9.4°F); BP (164°C, 327°F); DN (0.9062 g/mL at 25°C); LSG (0.91); VS (0.940 cP at 20°C); VD (4.08); REL DN vapor/air mixture (1.88 at 20°C); VP (2 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; subject to polymerization by heat or catalysts; usually contains an inhibitor such as tert-butyl catechol; reacts with strong oxidants; FP (54°C, 129°F); LFL/UFL (1.9%, 6.1%); AT (574°C, 1065°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 2, Flammability 2, Reactivity 2; explosive vapor-air mixtures may be formed above 54°C; flash-

back along vapor trail may occur; distant ignition possible; can react vigorously with oxidizing materials; incompatible with halogens, peroxides, aluminum, iron chloride, copper and catalysts for vinyl or ionic polymers; decomposes on heating producing carbon monoxide; use powder, water spray, alcohol-resistant foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, dizziness, sore throat, irritates eyes, skin and respiratory tract); contact (skin sensitization, dermatitis); ingestion (effects on kidneys and liver).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; if not breathing, provide artificial respiration; in case of ingestion, rinse mouth and get immediate medical attention..

**HUMAN TOXICITY DATA:** inhalation-human TCl<sub>0</sub> 600 ppm; toxic effect: any irritant effect on the skin, eyes, or mucous membranes.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; cough; dizziness; sore throat; drowsiness.

**CHRONIC HEALTH RISKS:** prolonged contact may cause dermatitis; may cause skin sensitization; may have effects on central nervous system, kidneys and liver.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (242 mg/m<sup>3</sup>); ACGIH TLV STEL 100 ppm (483 mg/m<sup>3</sup>); OSHA PEL CL 100 ppm (480 mg/m<sup>3</sup>); NIOSH REL TWA 50 ppm (240 mg/m<sup>3</sup>); NIOSH REL STEL 100 ppm (485 mg/m<sup>3</sup>); IDLH 700 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles; above 54°C, use a closed system of local exhaust ventilation and explosion-proof electrical equipment; use self-contained breathing apparatus in high vapor concentrations; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers; absorb remaining liquid with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry, well-ventilated location; keep in tightly closed containers; separate from strong oxidants.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** major use as a polymerization monomer, especially for polyesters.

**KEY REFERENCES:** 4; 5; 6; 7; 12; 14.

## **METHYLENE BISPHENYL ISOCYANATE (C<sub>15</sub>H<sub>10</sub>N<sub>2</sub>O<sub>2</sub>, 250.27)**

**CAS/DOT IDENTIFICATION #:** 101-68-8/UN2489

**SYNONYMS:** 4,4'-diphenylmethane diisocyanate, mdi, methylene bis(4-phenyl isocyanate), methylene di-p-phenylene ester of isocyanic acid.

**PHYSICAL PROPERTIES** : light-yellow, fused solid or crystals; odorless; soluble in acetone, benzene, kerosene, and nitrobenzene; insoluble in water at 20°C; MP (37.2°C, 99°F); BP (184°C, 363°F at 3mmHg); DN (1.197 g/mL at 70°C); LSG (1.19 at 122°F); ST (NA); VS (NA); CP (NA); HV (NA); VD (NA); VP ( $5 \times 10^{-6}$  mmHg at 77°F).

**CHEMICAL PROPERTIES**: combustible solid; polymerizes at 450°F; reacts with strong alkalis, acids, and alcohol; FP (390°C, 734°F); LFL/UFL (NA); AT (NA); HC (NA); HF (NA).

**EXPLOSION and FIRE CONCERNS**: combustible; NFPA rating (NA); reacts violently with alcohols and isocyanates; hazardous polymerization will occur; containers may explode under fire conditions; incompatible with amines, alcohols, water, acids, strong alkalis, and heat; heating to decomposition emits carbon monoxide, carbon dioxide, hydrogen cyanide, and oxides of nitrogen and sulfur; use water spray, dry chemical powder, carbon dioxide, or foam for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (dyspnea, coughing, chest pain, wheezing, reduced pulmonary function, headache, nausea, vomiting, asthma, laryngitis, irritates eyes, nose and throat); contact (dermatitis, eczema).

**FIRST AID**: wash eyes immediately with large amounts of water or normal saline solution; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if ingested, drink 1 or 2 glasses of water to dilute the chemical and get medical attention immediately.

**HUMAN TOXICITY DATA**: inhalation-human TClO 130ppb/30M.

**ACUTE HEALTH RISKS**: irritation of eyes, nose and throat; destructive to tissues of mucous membranes; respiratory sensitization; coughing; pulmonary secretions; chest discomfort; breathlessness; reduced pulmonary function; wheezing; laryngitis; burning sensation; headache; nausea; vomiting.

**CHRONIC HEALTH RISKS**: respiratory distress; asthma; respiratory impairments; probable cancer causing agent in humans; increased immune response and body temperature; may alter genetic material; allergic sensitizer.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 0.005 ppm; OSHA PEL CL 0.2 mg/m<sup>3</sup>(0.02 ppm); NIOSH REL TWA 0.05 mg/m<sup>3</sup> (0.005 ppm); NIOSH REL CL 0.2 mg/m<sup>3</sup>/10M (0.020 ppm); IDLH 75 mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear clean, waterproof protective clothing (coveralls, rubber boots, cap sleeves, etc.); clean rubber gloves are recommended; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP**: ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber equipped with effluent gas cleaning device; sweep up, place in a bag, and hold for waste disposal; avoid raising dust.

**DISPOSAL AND STORAGE METHODS**: absorb as much as possible with noncombustible materials such as dry earth, sand, or vermiculite, and place in a secured sanitary landfill; atomize large quantities in a suitable combustion chamber equipped with effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from amines, alcohols, acids, and strong alkalis.

**REGULATORY INFORMATION:** CA2; Reportable Quantity (RQ): 5000 lbs (2270kg); A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** useful in bonding rubber to rayon and nylon; used in two-component polyurethane coating systems used for aircraft, tank trucks, and truck trailers; also used to produce polyurethane lacquer coatings applied to certain automobile body components; other uses are in production of thermoplastic polyurethane resins and spandex fibers.

**KEY REFERENCES:** 2; 4; 5; 6; 11; 12; 13; 14.

**MOLYBDENUM (SOLUBLE AND INSOLUBLE COMPOUNDS (as Mo)),** Soluble and insoluble molybdenum compounds have variable molecular formulas and variable formula weights. The molecular formula for molybdenum is Mo. The formula weight for molybdenum is 95.95)

**CAS/DOT IDENTIFICATION #:** 7439-98-7/none

**SYNONYMS:** Synonyms vary depending upon the specific soluble or insoluble molybdenum compound. The synonyms for metallic molybdenum are as follow: molybdate, molbdenum metal.

**PHYSICAL PROPERTIES :** Appearance, odor, and other physical properties vary depending upon the specific soluble or insoluble molybdenum compound. Physical properties of metallic molybdenum and several specific soluble and insoluble compounds are provided for illustrative purposes (elemental molybdenum) silver-white cubic crystals or gray-black powder with a metallic luster; fairly soft when pure; soluble in hot concentrated nitric or sulfuric acids; not soluble in water; insoluble in dilute sulfuric acid, hydrochloric acid and hydrogen fluoride, ammonia, and sodium hydroxide; MP (2622°C, 4752°F); BP (4825°C, 8717°F); DN (10.28 g/cm<sup>3</sup>); SG (10.28); CP (24.1 J/K-mol crystal at 25°C); HV (142 kcal/g-atom); VD (NA); VP (1 mmHg at 3102°C); The following are examples of soluble molybdenum compounds; (molybdenum trioxide) white or slightly yellow to slightly bluish powder or solid; melts to dark-yellow liquid which solidifies to a yellowish-white mass; odorless; sparingly soluble in water; soluble in concentrated mineral acids, in solutions of alkali hydroxides, potassium bitartrate, or ammonia; MP (795°C, 1463°F); BP (1155°C, 2111°F); DN (4.696 g/cm<sup>3</sup> at 26°C); SG (4.7 at 20°C); CP (56.0 J/K-mol crystal at 25°C); VD (NA); VP (approximately 0 mmHg at 20°C); The following are examples of insoluble molybdenum compounds. (molybdenum disulfide) lustrous, lead-gray powder; synthetic form is black and lustrous; insoluble in water, dilute acids, and organic solvents; soluble in aqua regia and concentrated sulfuric acid; MP (1185°C, 2165°F); BP (decomposes in air); DN (5.06 g/cm<sup>3</sup> at 15°C); SG (4.7 at 20°C); CP (63.6 J/K-mol crystal at 25°C); VD (NA); VP (approximately 0 mmHg at 20°C); (lead molybdate) colorless to pale yellow solid; odorless; insoluble in water and alcohol; soluble in nitric acid; MP (1060 - 1070°C, 1940 - 1958°F); BP (decomposes at 760 mmHg); DN (6.8 g/cm<sup>3</sup>); SG (6.8); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** Chemical properties vary depending upon the specific soluble or insoluble molybdenum compound. Molybdenum is fairly stable at ordinary temperatures; less reactive than chromium (Cr) to acids; combines with oxygen to give the trioxide (MoO<sub>3</sub>) at red heat; slowly oxidized by steam; reacts with hot concentrated sulfuric acid, nitric acid, fused potassium chlorate or nitrate; at ordinary temperatures, attacked by fluorine; attacked by chlorine or bromine at very high temperatures; Molybdenum trioxide readily forms a series of polymeric compounds on combination with acids or bases; sublimes at higher temperatures, starting at 700°C (1292°F); reported to be photosensitive; forms molyb-

dates in excess alkali; Molybdenum disulfide begins to sublime at 450°C (842°F); decomposes on heating in air to molybdenum trioxide ( $\text{MoO}_3$ ) and in vacuum to dimolybdenum trisulfide ( $\text{Mo}_2\text{S}_3$ ); FP (NA); LFL/UFL (NA); AT (Molybdenum: 360°C, 680°F (layer); 720°C, 1328°F (cloud); Molybdenum disulfide 290°C, 554°F (layer); 570°C, 1058°F (cloud)).

**EXPLOSION and FIRE CONCERNS:** Molybdenum is a combustible solid in form of dust or powder; reacts violently with strong oxidants (e.g., bromine trifluoride, chlorine trifluoride, fluorine, sodium peroxide, lead dioxide, etc.); Molybdenum disulfide reacts violently with hydrogen peroxide and forms explosive mixtures with potassium nitrate; toxic gases and vapors (such as molybdenum oxide fume, sulfur dioxide gas, and carbon monoxide) may be released when insoluble compounds decompose; dry sand, dry dolomite, or dry graphite may be used to extinguish fires involving molybdenum and molybdenum disulfide; contact of soluble molybdenum compounds with alkali metals such as sodium and potassium or with molten magnesium may cause fires and explosions; toxic gases and vapors (such as ammonia and carbon monoxide) may be released when some soluble molybdenum compounds decompose.

**HEALTH SYMPTOMS:** inhalation (difficulty in breathing, irritates eyes, nose and throat); contact (listlessness, liver and kidney damage) ingestion (diarrhea, low weight, coma, heart failure).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingested, give large quantities of water immediately, then induce vomiting; seek prompt medical attention.

**HUMAN TOXICITY DATA:** no  $\text{LD}_{50}/\text{LC}_{50}$  information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** (Molybdenum and insoluble molybdenum compounds) irritation of eyes, nose and throat, weight loss, listlessness, diarrhea, and digestive disturbances in animals; symptoms of acute poisoning, based upon animal experiments, include coma, deaths from heart failure, liver and kidney damage. (Soluble molybdenum compounds (irritation of eyes, nose, and throat, loss of appetite, incoordination, dyspnea, anemia, and colic in animals.

**CHRONIC HEALTH RISKS:** (Molybdenum and insoluble molybdenum and insoluble compounds) based upon animal experiments, accumulation of molybdenum dust in the lungs, spleen, and heart, showed a decrease of DNA and RNA in the kidneys, spleen, and liver; exposure to molybdenum dust from alloys or carbides caused "hard-metal lung disease" in humans. (Soluble molybdenum compounds) repeated exposure to soluble molybdenum compounds, based on animals data, suggests an association with the gout; can cause anemia in animals; exposure to molybdenum trioxide ( $\text{MoO}_3$ ), over a period of 3-7 years, has caused pneumoconiosis in workers.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg (Mo)/ $\text{m}^3$  (soluble compounds), 10 mg(Mo)/ $\text{m}^3$  (insoluble compound); OSHA PEL TWA 15 mg/ $\text{m}^3$  (total dust), 15 mg/ $\text{m}^3$  (insoluble compounds), 5 mg/ $\text{m}^3$  (soluble compounds); NIOSH IDLH 5000 mg (as Mo)/ $\text{m}^3$  (insoluble compounds), 1000 mg (as Mo)/ $\text{m}^3$  (soluble compounds).

**PERSONAL PROTECTION:** wear clean, waterproof protective clothing (coveralls, rubber boots, cap sleeves, etc.); clean rubber gloves are recommended; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; collect spilled material in a safe manner and deposit in sealed containers; liquids containing soluble or insoluble molybdenum compounds should be absorbed in inert materials, such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** Molybdenum and insoluble or soluble molybdenum compounds may be disposed of in a secured, sanitary landfill; storage should be in sealed containers in a cool, dry location; separate soluble molybdenum compounds from alkali metals (e.g., sodium, potassium, or molten magnesium); molybdenum and insoluble molybdenum compounds should be kept away from strong oxidizers.

**REGULATORY INFORMATION:** S1; S2; S3; A1; CAL; DOT classification (none); labels required (none).

**OTHER COMMENTS:** Molybdenum and insoluble molybdenum compounds may be used as lubricants in greases, oil dispersions, resin-bonded films, and dry powders; as catalysts in petroleum refining and in organic synthesis of medicinals; use as alloying agents in production of iron and steel; use in metal brazing and in manufacture of cutting tools. Soluble molybdenum compounds may be used in electroplating process, in formulation of corrosion inhibitors, and in pigments for paints, lacquers, and coloring animal fibers and hair; use in enamel processes for adherence of glass-like coatings to ceramics and metals; use in leather and skin tanning; also utilized as chlorination catalysts, as a catalyst in desulfurifications of gasoline, as an intermediate for organo-metallic compounds, and as a reagent for determination of phosphorus and lead.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 16.

### **MONOMETHYL ANILINE (C<sub>6</sub>H<sub>5</sub>NHCH<sub>3</sub>, 107.17)**

**CAS/DOT IDENTIFICATION #:** 100-61-8/UN2294

**SYNONYMS:** n-methylaniline, n-methylbenzenamine, n-methylphenylamine, n-monomethylaniline, n-phenylmethylamine.

**PHYSICAL PROPERTIES :** colorless or slightly yellow, oily liquid; turns brown on exposure to air; discolors on standing; weak, ammonia-like odor; practically insoluble in water; soluble in alcohol and ether; MP (-57°C, -70.6°F); BP (194-196°C, 381-385°F); DN (0.989 g/mL at 20°C); LSG (0.99); ST (36.90 mN/m at 25°C); VS (2.042 mPa-s at 25°C); HV (53.1 kJ/mol at 25°C); VD (3.7); REL DN vapor/air mixture (1.0 at 20°C); VP (0.3 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with strong acids and strong oxidizers; will attack some forms of plastic; FP (79.5°C, 175°F); LFL/UFL (unknown); AT (unknown); HC (-3.9000 x 10<sup>9</sup> J/kmol).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating (NA); explosive vapor/air mixtures may be formed above 80°C; violent reaction with strong acids and oxidants; attacks some plastics; decomposes on heating and on burning producing toxic fumes of oxides of nitrogen and aniline; use carbon dioxide, powder or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (blue lips or fingernails, blue skin, cough, dizziness, headache, sore throat, labored breathing); skin absorption (weakness, dizziness, headache, blood effects); ingestion (abdominal pain, nausea, labored breathing, bluish discoloration of skin, headache, dizziness, liver damage, injury to kidneys).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxy-

gen; if not breathing, provide respiratory support; in case of ingestion, rinse mouth and induce vomiting; get immediate medical attention..

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; dizziness; headache; cyanosis; dyspnea; cough; sore throat; pulmonary edema; abdominal pain; nausea; may cause effects on blood, resulting in formation of methemoglobin.

**CHRONIC HEALTH RISKS:** may cause skin sensitization; may have effects on blood, resulting in methemoglobinemia; liver damage; damage to kidneys.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm(2.2mg/m<sup>3</sup>)(skin); OSHA PEL TWA 2 ppm (9 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.5 ppm (2 mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; wear splash-proof safety goggles in combination with breathing protection; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); above 80°C, use a closed system of local exhaust ventilation; for extra personal protection, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers or absorb with noncombustible materials (e.g., dry earth, sand, vermiculite); remove all sources of ignition; note: (this chemical should not be allowed to enter the environment).

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent and remove to a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; keep in a well-ventilated room; separate from strong acids, strong oxidants, food and feedstuffs.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used in organic synthesis; useful as a solvent; used as an acid acceptor.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **MORPHOLINE (C<sub>4</sub>H<sub>9</sub>NO, 87.14)**

**CAS/DOT IDENTIFICATION #:** 110-91-8/UN2054

**SYNONYMS:** diethylene imidoxide, diethylene oximide, diethylenimide oxide, tetrahydro-1,4-isoxazine, tetrahydro-p-oxazine.

**PHYSICAL PROPERTIES :** colorless liquid; mobile, hygroscopic, liquid; weak, ammonia- or fish-like odor; a solid below 23°F; does not form an azeotrope with water; miscible with water; miscible with acetone, benzene, ether, castor oil, methanol, ethanol, ethylene, glycol, linseed oil, turpentine, and pine oil; immiscible with concentrated sodium hydroxide solution; MP (-5°C, 23°F); BP (129°C, 264°F); DN (1.007 g/mL at 20°C); LSG (1.007); ST (37.5 dynes/cm at 20°C); VS (2.23 cP at 20°C); HV (43.96 kJ/mol at 25°C); VD (3.00); VP (6 mmHg at 20°C, 10 mmHg at 23°C); OT (0.01 ppm).

**CHEMICAL PROPERTIES:** combustible liquid; corrosive to metals; strong base; reacts with acid, oxidizing materials, and nitro compounds; forms alkaline solutions; FP (35°C, 95°F); LFL/UFL (1.8%, 11.0%); AT (310°C, 590°F).

**EXPLOSION and FIRE CONCERNS:** flammable and combustible liquid; NFPA rating Health 3, Flammability 3, Reactivity 0; flashback along vapor trail may occur; vapor may be explosive if ignited in an enclosed area; volatile with steam; very dangerous fire hazard when exposed to flame, heat, or oxidizers; mixtures with nitromethane are explosive; contact with cellulose nitrate of high surface area may result in spontaneous ignitions; combustion by-products include ammonia and nitrogen oxides; use flooding quantities of water, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, headache, difficult breathing, irritates eyes, nose and throat); skin absorption (respiratory system, visual disturbances, cough); contact (skin and eye irritation).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if ingested, drink plenty of water or milk, and then immediately induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; skin and eye burns; nausea; headache; cough; irritation of mucous membranes; visual disturbances; nose irritation.

**CHRONIC HEALTH RISKS:** kidney damage; damage to the liver; may alter genetic material.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 20 ppm(skin); OSHA PEL TWA 20 ppm (70 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 20 ppm (70 mg/m<sup>3</sup>); NIOSH REL STEL 30 ppm (105 mg/m<sup>3</sup>)(skin); IDLH 1400 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, including chemical-resistant gloves; wear positive pressure self-contained breathing apparatus; equipment should not have copper or copper alloy parts.

**SPILL CLEAN-UP:** stop or control leak if possible; use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** pour onto thick layer of sand-soda ash mixture, and burn in incinerator with scrap wood or paper; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; outside storage preferred; inside storage should be in a standard flammable liquids storage room or cabinet; separate from strong oxidizers and acids.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a cheap solvent for resins, waxes, casein, and dyes; fatty acid salts of morpholine are used as surface-active agents and emulsifiers; other compounds of morpholine are useful as corrosion inhibitors, plasticizers, viscosity improvers, antioxidants, insecticides, local anesthetics and antiseptics.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 11; 14.

**NAPHTHA (COAL TAR) (C<sub>7</sub>H<sub>8</sub>-C<sub>8</sub>H<sub>10</sub> (approximately), 110 (approximately)).**

**CAS/DOT IDENTIFICATION #:** 8030-30-6/UN1256 (naphtha solvent), UN 2553 (naphtha).

**SYNONYMS:** benzin, crude solvent coal tar naphtha, high solvent naphtha, hydrotreated naphtha, naphtha, petroleum benzin, petroleum distillates (naphtha), petroleum naphtha, petroleum oil.

**PHYSICAL PROPERTIES :** reddish-brown to clear, colorless liquid; aromatic odor; very mobile liquid; does not solidify in the cold; miscible with absolute alcohol, chloroform, benzene, ether, carbon tetrachloride, carbon disulfide and oils (except castor oils); insoluble in water; soluble in benzene, toluene, xylene, etc.; MP (-73°C, -99.4°F); BP (110-190°C, 230-374°F); DN/SG (0.89-0.97); ST (19-23 dynes/cm, 0.019-0.023 N/m liquid at 20°C); VD (2.5); HV (130-150 Btu/lb, 71-81 cal/g, 3.0 x 10<sup>5</sup> - 3.4 x 10<sup>5</sup> J/kg); VP (< 5 mmHg at 20°C); LIQ-UID/WATER INTERFACIAL TENSION (39-51 dynes/cm, 0.039-0.051 N/m at 20°C); RATIO OF SPECIFIC HEATS OF VAPOR (1.030 (estimated)).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with strong oxidizers; will attack some forms of plastics, rubber, and coatings; FP (38-43°C, 100-109°F); LFL/UFL (1.1%, 5.9%); AT (482-510°C, 900-950°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; flammable liquid when exposed to heat and flame; slight explosion hazard; NFPA rating Health 2, Flammability 2, Reactivity 0; vapors mixed with air explode if ignited; contact with strong oxidizing agents may cause fires and explosions; toxic gases and vapor, such as carbon monoxide, may be released in a fire; use dry chemical, alcohol foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, lightheadedness, coughing, pulmonary edema, shortness of breath, irritates eyes, nose and throat); ingestion (abdominal pain, nausea, vomiting, diarrhea, loss of appetite, changes in menstrual cycle); contact (chemical pneumonitis, dry, cracked skin).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, seek immediate medical attention.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 3 pph/5M; intravenous-man LDLo 27 mg/kg; toxic effect: pulmonary system; probable oral lethal dose (human) 0.5-5g/kg, between 1 ounce and 1 pint (or 1 lb) for 70 kg person (150 lb).

**ACUTE HEALTH RISKS:** irritation to eyes, nose, and throat; irritation to mucous membranes; neurotoxic effects, including anesthesia, euphoria, abuse, vertigo, and limb numbness; signs of drunkenness; headache; dizziness; coughing; choking; gagging; dyspnea; nausea; vomiting; diarrhea; epigastric discomfort; loss of appetite; impairment of motor action; muscle weakness; chemical pneumonitis, with pulmonary edema and hemorrhagic frothy sputum; bacterial pneumonia may develop; indications of slight renal tubular effects were reported after exposure to rubber solvent; disturbances in menstrual cycle; disturbance of ovarian function; reduced estrogen level in the blood; bronchospasm; necrosis of bronchial, bronchiolar, and alveolar tissues; vascular thrombosis; residual small airway abnormalities; can cause reversible cerebral edema; fatty infiltration of the liver may occur; may cause myocarditis and myocardial infarction; very high concentrations can cause convulsions and death.

**CHRONIC HEALTH RISKS:** a rubber solvent induced chromosomal aberrations in human whole-blood cultures; repeated exposure can damage the nervous system, including headache, fatigue, poor concentration, emotional instability, impaired memory and other intellectual functions; chronic neurotoxic effects include motor polyneuropathy; prolonged contact can cause drying and cracking of skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (none); OSHA PEL TWA 100 ppm (400 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (400 mg/m<sup>3</sup>); IDLH 1000 ppm (based on 10% of lower explosive limit (LEL) for safety considerations).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, solvent-resistant gloves, lab coat, apron or coveralls; nitrile and neoprene rubbers or polyvinyl alcohol is recommended as protective materials; wear splash-proof chemical goggles when working with liquid; enclose operations and use local exhaust ventilation at the site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; use explosion-proof electrical equipment and non-sparking tools; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; absorb liquids with dry earth, sand or other noncombustible material and transfer to sealed containers; flush remaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion; a vapor suppressing foam may be used to reduce vapors; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquids in dry earth, sand or vermiculite, and place in a secured, sanitary landfill; large quantities may be disposed of by atomizing in a suitable combustion chamber; store in a cool, dry area; use only with adequate ventilation; store in tightly closed containers; metal containers involving the transfer of 5 gallons or more should be bonded and grounded; separate from strong oxidizers (such as chlorine, bromine and fluorine).

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** coal tar naphtha is a mixture of aromatic hydrocarbons, mainly toluene, xylene, and cumene; however, those coal tar naphthas with low boiling points contain appreciable amounts of benzene; used as a diluent in coatings, inks, paints, resins, and cements; used in the preparation of coumarone and indene; utilized as a solvent in the rubber industry; utilized in formulations of nitrocellulose and ethyl cellulose.

**KEY REFERENCES:** 3; 4; 5; 6; 15; 16.

### **NAPHTHALENE (C<sub>10</sub>H<sub>8</sub>, 128.18)**

**CAS/DOT IDENTIFICATION #:** 91-20-3/UN1334 (crude or refined); UN 2304 (molten)

**SYNONYMS:** moth balls, moth flakes, naphthalin, naphthene, tar camphor, white tar.

**PHYSICAL PROPERTIES :** white solid in flake, cake, or powder form; aromatic odor; odor of moth balls; very soluble in ether, hydronaphthalenes, carbon tetrachloride, carbon disulfide, and in fixed and volatile oils; very slightly soluble in water; miscible with phenols, ethers, chloroform, benzene, coal-tar naphtha, acetone, and decadronaphthalene; MP (80°C, 176°F); BP (218°C, 424°F); DN (1.162 g/cm<sup>3</sup> at 20°C); SG (1.16); ST (31.8 dynes/cm

liquid at 100°C); CP (159.28 J/K-mol at 15.5°C and 101.325 kPa); HV (43.5 kJ/mole); VD (4.42); VP (0.05 mmHg at 20°C, 1.0 mmHg at 53°C); OT(6.80 ppm in water).

**CHEMICAL PROPERTIES:** combustible solid; sublimates at temperature above melting point; volatilizes at room temperature; melted naphthalene attacks some forms of plastics, rubber, and coatings; reacts with oxidizing materials and chromic anhydride; FP (79°C, 174°F); LFL/UFL(0.9%, 5.9%); AT (526°C, 979°F); HC (-9287 cal/g, -16,720 Btu/lb, -388.8 x 10<sup>5</sup> J/kg); HF (150.3 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible solid; flammable when exposed to heat or flame; NFPA rating Health 2, Flammability 2, Reactivity 0; solid gives off flammable vapor when heated; dust explodes in air when subjected to source of ignition; reacts explosively with dinitrogen pentaoxide; violent reaction with chromium trioxide and aluminum chloride + benzoyl chloride; reacts vigorously with strong oxidizers and chromic anhydride; decomposition emits toxic gases and vapors including carbon monoxide; use water, carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat, headaches, dizziness, nausea); skin absorption (severe eye irritation, injuries to the cornea, cataracts, optical neuritis); ingestion (hemolytic anemia, hemoglobinuria).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin promptly with large amounts of soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** unreported-human LDLo 29mg/kg; unreported-man LDLo 74 mg/kg; oral-child LDLo 100mg/kg.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; destructive to tissues of mucous membranes; nausea; vomiting; headache; diaphoresis (perspiration); fever; convulsions; hematuria; anemia; renal shutdown; jaundice; abdominal pain; irritation of bladder; optical neuritis; damage to the cornea; cyanosis; coma.

**CHRONIC HEALTH RISKS:** possible dermatitis; carcinogen; target organs: eyes, blood, liver, kidneys, skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm; ACGIH TLV STEL 15 ppm; OSHA PEL TWA 10ppm (50mg/m<sup>3</sup>); OSHA PEL STEL 15 ppm; NIOSH REL TWA 10ppm (50mg/m<sup>3</sup>); NIOSH REL STEL 15 ppm (75 mg/m<sup>3</sup>); IDLH 250ppm.

**PERSONAL PROTECTION:** wear coveralls, rubber apron, rubber shoes or boots; wear chemical-resistant rubber gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; shovel small quantities into suitable dry container and burn in a safe place (such as a fume hood); remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** cautiously ignite small amounts in open areas; dissolve in flammable solvent and spray into incinerator; store in a cool, dry location separate from oxidizing materials; may be stored under nitrogen gas.

**REGULATORY INFORMATION** CA2; S3; S40-j; R3; R4; R5; R8; R9; U waste # (U165); Reportable Quantity (RQ): 100 lbs. (45.4kg); Sf1; Sf3; CW1; CW2; CW3; CW4; CW5; T120-a; A1; CAL; DOT hazard class/division (4.1); labels (flammable solid).

**OTHER COMMENTS:** used in the manufacture of phthalic and anthranilic acids, naphthols, naphthylamines, sulfonic acid and similar compounds used in the dye industry; used

in the manufacture of hydronaphthalenes which are used as solvents in lubricants and motor oils; use as a moth repellent and insecticide is decreasing due to the introduction of chlorinated compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

**alpha-NAPHTHYLAMINE (C<sub>10</sub>H<sub>7</sub>NH<sub>2</sub>, 143.20)**

**CAS/DOT IDENTIFICATION #:** 134-32-7/UN2077

**SYNONYMS:** 1-aminonaphthalene, 1-naphthalenamine, 1-naphthylamine.

**PHYSICAL PROPERTIES:** colorless, crystalline solid; darkens to a reddish-purple color on exposure to air; ammonia-like odor; very slightly soluble in water; freely soluble in alcohol and ether; MP (50°C, 122°F); BP (301°C, 574°F); DN (1.131 g/cm<sup>3</sup>); SG (1.12 at 20°C); VD (4.93); VP (1 mmHg at 104°C (220°F)).

**CHEMICAL PROPERTIES:** stable in cold in absence of air; sensitive to light; dark color does not affect purity; air sensitive; oxidizes in presence of air; reduces warm ammoniacal silver nitrate; hazardous polymerization will not occur; incompatible with strong acids and strong oxidizing agents; FP (157°C, 315°F); LFL/UFL (data not available); AT (data not available).

**EXPLOSION and FIRE CONCERNS:** combustible solid; volatile with steam; NFPA rating Health 2, Flammability 1, Reactivity 0; sublimes; evolves a vapor that is flammable and explosive at elevated temperatures; incompatible with nitrous acid; decomposition liberates toxic fumes of oxides of nitrogen; use carbon dioxide or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, breathing difficulty); skin absorption (can cause nervous system injury, ataxia); ingestion (can cause bladder injury, can cause blood disorders); skin contact (can cause allergic skin reaction, can cause sensitization by skin contact, may cause tumors).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; cleanse affected areas of skin with plenty of soap and water; administer oxygen if breathing is difficult; administer artificial respiration if breathing has stopped if this chemical has been swallowed, seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; dyspnea; hemorrhagic cystitis; ataxia; hematuria (blood in urine); dysuria; methemoglobinemia.

**CHRONIC HEALTH RISKS:** confirmed human carcinogen; prolonged exposure may produce tumors and cancers of the bladder; human mutation data has been reported; extremely hazardous to contact in anyway.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA confirmed human carcinogen; OSHA PEL (1910.1004) potential occupational carcinogen; NIOSH REL potential occupational carcinogen; IDLH (not determined) potential occupational carcinogen.

**PERSONAL PROTECTION:** wear impervious, fully protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; chemical should

be handled only in a fume hood; avoid direct physical contact, since this material is considered to be extremely hazardous; no exposure by any route should be permitted; appropriate respirators are needed in areas where the potential for high exposure levels exists; use self-contained breathing apparatus in unknown concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep up and place in an appropriate container; hold for disposal; wash contaminated surfaces to remove any residues.

**DISPOSAL AND STORAGE METHODS:** (1) spill may be treated with 0.1% hydrochloric acid, and then cautiously ignited in open areas; (2) pour onto thick layer of sand-soda ash mixture, and burn in incinerator with scrap wood or paper; (3) dissolve in flammable solvent and burn in a chemical incinerator equipped with afterburner and scrubber; storage should be in tightly closed containers in a cool, dry place; maintain adequate ventilation; store only with compatible chemicals; avoid contact with strong acids, strong oxidizing agents, heat and open flame.

**REGULATORY INFORMATION:** R4; U waste # (U167); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf3; A1; A4; CAL; DOT hazard class/division (6.1); label (keep away from food).

**OTHER COMMENTS:** alpha-Naphthylamine is an extremely toxic chemical in any of its physical forms, such as flake, dust, liquid, or vapor; may be fatal if absorbed through skin, if inhaled, or swallowed; personnel should be completely protected against physical contact with this chemical; this chemical has been used in the manufacture of dyes and toning prints made with cerium salts; the hydrochloride with sulfanilic acid is a reagent for nitrate.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 14

### **beta-NAPHTHYLAMINE (C<sub>10</sub>H<sub>7</sub>NH<sub>2</sub>, 143.20)**

**CAS/DOT IDENTIFICATION #:** 91-59-8/UN1650

**SYNONYMS:** 2-aminonaphthalene, 2-naphthalenamine, 2-naphthylamine.

**PHYSICAL PROPERTIES:** white to reddish, lustrous crystals; darkens in air to a red-dish-purple color; faint aromatic odor; soluble in many organic solvents; soluble in hot water, alcohol, and ether; MP (111 - 113°C, 232 - 235°F); BP (306°C, 583°F); DN (1.061 g/cm<sup>3</sup> at 98°C); SG (1.06 at 208°F); VD (NA); VP (1 mmHg at 108°C (226°F)); OT (1.4 - 1.9 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** stable in cold in absence of air; undergoes oxidation in presence of air; not corrosive; reduces warm ammoniacal silver nitrate; incompatible with strong acids and strong oxidizing agents; FP (157°C, 315°F); LFL/UFL (data not available); AT (data not available).

**EXPLOSION and FIRE CONCERNS:** combustible solid; volatile with steam; NFPA rating (not rated); evolves a vapor that is flammable and explosive at elevated temperatures; incompatible with nitrous acid; decomposition liberates toxic fumes of oxides of nitrogen; use carbon dioxide, dry chemical powder, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, breathing difficulty); skin absorption (can cause nervous system injury, ataxia); ingestion (can cause bladder injury, can cause blood disorders); skin contact (can cause allergic skin reaction, can cause sensitization by skin contact, may cause tumors).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; cleanse affected areas of skin with plenty of soap and water; administer oxygen if breathing is difficult; administer artificial respiration if breathing has stopped; if this chemical has been swallowed, seek prompt medical attention.

**HUMAN TOXICITY DATA:** DNA damage – human fibroblast 50 $\mu$ mol/L; no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupation exposure.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; dyspnea; hemorrhagic cystitis; ataxia; hematuria (blood in urine); dysuria; methemoglobinemia.

**CHRONIC HEALTH RISKS:** confirmed human carcinogen; prolonged exposure may produce tumors and cancers of the bladder; human mutation data has been reported; extremely hazardous to contact in anyway.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA confirmed human carcinogen; OSHA PEL (1910.1009) potential occupational carcinogen; NIOSH REL potential occupational carcinogen; IDLH (not determined) potential occupational carcinogen.

**PERSONAL PROTECTION:** wear impervious, fully protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; chemical should be handled only in a fume hood; avoid direct physical contact, since this material is considered to be extremely hazardous; no exposure by any route should be permitted; appropriate respirators are needed in areas where the potential for high exposure levels exists; use self-contained breathing apparatus in unknown concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep up and place in an appropriate container; hold for disposal; wash contaminated surfaces to remove any residues.

**DISPOSAL AND STORAGE METHODS:** (1) spill may be treated with 0.1% hydrochloric acid, and then cautiously ignited in open areas; (2) pour onto thick layer of sand-soda ash mixture, and burn in incinerator with scrap wood or paper; (3) dissolve in flammable solvent and burn in a chemical incinerator equipped with afterburner and scrubber; storage should be in tightly closed containers in a cool, dry place; maintain adequate ventilation; store only with compatible chemicals; avoid contact with strong acids, strong oxidizing agents, heat and open flame.

**REGULATORY INFORMATION:** R4; U waste # (U168); Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf3; A1; A4; CAL; DOT hazard class/division (6.1); label (keep away from food).

**OTHER COMMENTS:** beta-Naphthylamine is an extremely toxic chemical in any of its physical forms, such as flake, dust, liquid, or vapor; may be fatal if absorbed through skin, if inhaled, or swallowed; personnel should be completely protected against physical contact with this chemical; this chemical has formerly been used in the manufacture of dyes and as an anti-oxidant in rubber.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 14

**NICKEL CARBONYL (Ni(CO)<sub>4</sub>, 170.7)**

**CAS/DOT IDENTIFICATION #:** 13463-39-3/UN1259

**SYNONYMS:** nickel tetracarbonyl, tetracarbonyl nickel.

**PHYSICAL PROPERTIES :** colorless to yellow liquid; a gas above 110°F; sooty or musty odor; soluble in alcohol, benzene, chloroform, acetone, and carbon tetrachloride; soluble in aqua regia, ether, and nitric acid; insoluble in dilute acid, dilute alkali and water; MP(-25°C, -13°F); BP (43°C, 109°F); DN (1.318 g/mL at 17°C); LSG (1.32 at 17°C); ST (15.9 dynes/cm<sup>3</sup> at 20°C); VS (0.212 cP at 25°C); HV (72 Btu/lb, 1.7 x 10<sup>-5</sup> J/kg, 40 cal/g); VD (5.95 at 50°C); VP (400 mmHg at 25.8°C, 321 mmHg at 20°C); OT (1 - 3 ppm)..

**CHEMICAL PROPERTIES:** flammable liquid; decays spontaneously in air with a half-time of approximately 30 minutes; will attack some forms of plastics, rubber, and coatings; oxidizes in air; readily attacked by oxidizing agents with liberation of carbon monoxide and formation of corresponding salt; reacts vigorously with nitric acid, halogens, and oxidizing materials; unreactive with aqueous acids and alkalis; vapor is rapidly decomposed by oxygen to an amorphous hydrous nickel carbonate oxide; sulfuric acid liberate carbon monoxide and nickelous salts; carbon disulfide yields nickel sulfide and carbon; 10 ppm in atmosphere sufficiently imparts luminosity to alcohol or carbon monoxide flames; rapidly volatilizes at room temperature; FP (<-20°C, <-4°F); LFL/UFL (2%, 34%); AT (60°C, 140°F); HC (-2,970 Btu/lb, -69.0 J/kg, -1,650 cal/g).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 4, Flammability 3, Reactivity 3; very dangerous fire hazard; moderate explosion hazard; explodes when heated to about 60°C; closed containers may rupture violently in fire; flashback along vapor trail may occur; explosive reaction with liquid bromine, mercury and oxygen, and oxygen and butane; reacts violently with dinitrogen tetroxide, air, and oxygen; reaction with tetrachloropropadiene forms explosive dicarbonyl trichloropropenyl dinickel chloride dimer; decomposition or contact with acid emits highly toxic fumes of carbon monoxide; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (severe shortness of breath, build-up of fluid in the lungs (pulmonary edema), coughing, irritates nose, throat, and lungs); skin absorption (headache, dizziness, giddiness, nausea, and confusion); contact (itching, skin rash, severe eye burns).

**HUMAN TOXICITY DATA:** inhalation-human TClO 7 mg/m<sup>3</sup>; toxic effect: central nervous system; inhalation-human LClO 30 pm/30M; EPA Group B2, probable carcinogen in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; headache; vertigo; dizziness; giddiness; weakness; convulsions; hallucinations; delirium; nausea; vomiting; diarrhea; rapid respiration; coughing; pain and tightness in the chest; pulmonary edema; cerebral edema; diffuse interstitial pneumonitis; systemic effects on the brain; epigastric pain; substernal pain; cyanosis; leukocytosis (increased blood leukocytes); death.

**CHRONIC HEALTH RISKS:** lung cancer; nasal sinus cancer; reproductive effects; permanent lung damage; kidney damage; hepatic (liver) degeneration; skin allergy; nickel contact dermatitis; burning sensation; itching; erythema (redness); nodular eruptions.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05 ppm (0.12 mg/m<sup>3</sup>); OSH PEL TWA 0.001 ppm (0.007 mg/m<sup>3</sup>); NIOSH REL TWA 0.001 ppm (0.007 mg/m<sup>3</sup>); IDLH 2 ppm.

**PERSONAL PROTECTION:** wear protective clothing (suits, gloves, footwear, headgear, etc.); wear splash-proof safety goggles and face shield when working with liquid; an approved self-contained breathing apparatus is recommended in areas where exposure would be above the PEL (0.001 ppm); eyewash fountains and quick drench facilities should be provided within the immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use appropriate foam to blanket release and suppress vapors; absorb small quantities on paper towels and evaporate in a fume hood; absorb liquid in vermiculite, dry sand, earth, or a similar material and deposit in sealed containers; keep out of a confined space, such as a sewer, because of the danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand, or vermiculite and place in a sanitary landfill; atomize large quantities in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in tightly closed containers in a cool, well-ventilated area; metal containers should be grounded and bonded; keep away from strong acids, flammable materials and halogens; outside or detached storage is preferred.

**REGULATORY INFORMATION:** R4; P waste # (P073); Reportable Quantity (RQ): 10 lbs (4.54kg); Sf1; Sf2; A1; A5; CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid).

**OTHER COMMENTS:** used as a chemical intermediate for manufacture of high purity nickel; catalyst for manufacture of acrylic and methacrylic esters; an effective catalyst in the carbonylation reaction and for the manufacture of tetrahydrofuryl alcohol; use in glass plating and continuous nickel coatings on steel and other metals.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 14; 15; 16; 19.

**NICKEL, METAL AND INSOLUBLE COMPOUNDS** (The molecular formula for metallic nickel is Ni. The insoluble compounds of nickel have variable molecular formulas. The molecular formula for nickel carbonate is  $\text{CNiO}_3$ ; the molecular formula for nickel sulfide is  $\text{NiS}$ . The formula weight for metallic nickel is 58.70. The insoluble compounds of nickel have variable formula weights. The formula weight for nickel carbonate is 118.72; the formula weight for nickel sulfide is 90.77.)

**CAS/DOT IDENTIFICATION #:** The CAS # for nickel is 7440-02-0. The insoluble compounds of nickel have variable CAS #'s. The CAS # for nickel carbonate is 3333-67-3; the CAS # for nickel sulfide is 16812-54-7. The DOT Identification number for nickel and the insoluble compounds of nickel is not available.

**SYNONYMS:** (nickel) elemental nickel, nickel catalyst, nickel metal, raney alloy, raney nickel; (nickel carbonate) basic nickel carbonate, carbon acid nickel salt (1:1), nickelous carbonate; (nickel sulfide) mononickel monosulfide, nickel (II) sulfide, nickel monosulfide, nickelous sulfide.

**PHYSICAL PROPERTIES :** (nickel) lustrous, silvery metal or solid; hard, malleable and ductile; crystallizes as metallic cubes; odorless; soluble in dilute nitric acid; slightly soluble in hydrochloric acid and sulfuric acid; insoluble in water and ammonia; five naturally occurring isotopes; MP (1455°C, 2651°F); BP (2730°C, 4946°F); DN (8.90 g/cm<sup>3</sup> at 20°C); SG (8.90); CP (6.23 cal/g-atom/°C); VP (1 mmHg at 1810°C); MOH'S HARDNESS (3.8); (nickel carbonate) rhombic, light-green crystals or solid; soluble in dilute acid; insoluble in water; MP (decomposes); DN (4.39 g/cm<sup>3</sup>); SG (4.39); (nickel sulfide) yellow hexagonal crystals; insoluble in water; MP (976°C, 1788.8°F); DN (5.5 g/cm<sup>3</sup>); SG (5.5); CP (47.1 J/K mol crystal at 25°C).

**CHEMICAL PROPERTIES:** (nickel) stable in air at ordinary temperature; excellent resistance to corrosion; burns in oxygen, forming nickel oxide; not affected by water; decomposes steam at a red heat; slowly attacked by dilute hydrochloric or sulfuric acid; readily at-

tacked by nitric acid; not attacked by fused alkali hydroxides; FP (NA); LFL/UFL (NA); AT (NA); HC (NA);  $LH_f$  (73 cal/g); ER (6.844  $\mu\text{ohm/cm}$  at 20°C); (nickel carbonate) FP (NA); LFL/UFL (NA); AT (NA); HC (NA); (nickel sulfide) FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-82.0 kJ/mol crystal at 25°C);  $H_f$ (30.1 kJ/mol at 1249K)

**EXPLOSION and FIRE CONCERNS:** (nickel) flammable solid; NFPA rating Health 2, Flammability 4, Reactivity 1; pyrophoric when dry; powders may ignite spontaneously in air; may ignite on contact with air or moist air; may burn rapidly with flare-burning effect; reacts vigorously or explosively on contact with water; may decompose explosively when heated or involved in a fire; may re-ignite after fire is extinguished; runoff may create fire or explosion hazard; violent reaction with fluorine, ammonium nitrate, hydrazine, ammonia, and performic acid; mixtures containing potassium perchlorate with nickel and titanium powder and infusorial earth gave severe explosions during a friction test; a mixture of powdered nickel and sulfur or selenium will react incandescently; nickel powder will ignite on contact with bromine pentafluoride at ambient or slightly elevated temperatures; addition of peroxyformic acid to powdered nickel will result in an explosion; reacts explosively upon contact with fused ammonium nitrate at temperatures below 200°C; mixture of nickel and nitril fluoride will become incandescent if slightly warmed; incompatible with aluminum, aluminum trichloride, ethylene, p-dioxan, hydrogen, methanol, non-metals, oxidants, and sulfur compounds; violent decomposition reactions of nickel metal/nickel compounds may release toxic gases and vapors, such as nickel carbonyl; use flooding quantities of water, dry chemical, graphite, or dry earth for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (chronic irritation of upper respiratory tract, loss of sense of smell, bronchial asthma, pulmonary fibrosis, pneumoconiosis, increase risk of nasal and lung cancer); ingestion (vomiting, diarrhea, nausea, headache, giddiness, lassitude, tremor, respiratory problems, death); contact (dermatitis, eczema).

**HUMAN TOXICITY DATA:** There is inadequate evidence in humans for the carcinogenicity of metallic nickel and nickel alloys; nickel compounds are carcinogenic to humans (Group 1); metallic nickel is possibly carcinogenic to humans (Group 2B); EPA inhalation unit risk estimates of  $2.4 \times 10^{-4} \mu\text{g}/\text{m}^3$  for nickel refiner dusts and  $4.8 \times 10^{-4} \mu\text{g}/\text{m}^3$  for nickel subsulfide; EPA classifies nickel refiner dust and nickel subsulfide as Group A, human carcinogens.

**ACUTE HEALTH RISKS:** (nickel, nickel compounds) irritation of skin, eyes, and respiratory tract; vomiting; diarrhea; tremor; respiratory problems; nausea; headache; giddiness; lassitude; death.

**CHRONIC HEALTH RISKS:** (nickel, nickel compounds) lung and sinus cancer; pulmonary fibrosis; pulmonary edema; asthma; skin allergy; itching; redness and bumps; reproductive damage in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg(Ni)/m<sup>3</sup>; OSHA PEL TWA (insoluble compounds) 1mg(Ni)/m<sup>3</sup>; NIOSH REL TWA (inorganic nickel) 0.015 mg(Ni)/m<sup>3</sup>; IDLH 10mg(Ni)/m<sup>3</sup>.

**PERSONAL PROTECTION:** use laboratory protective equipment (lab coat, gloves, footwear, vent hood); use polyvinyl chloride, not rubber, for gloves; wear dust-proof goggles or face shield when working with powders or dusts; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** shovel powdered material and deposit in sealed containers; liquid containing nickel should be absorbed in vermiculite, dry sand, earth, or a similar material; keep nickel powder out of a confined space, such as a sewer, because of the danger or explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** recycle, if possible; nickel treatment at high pH, plus clarification, is capable of reducing residual nickel concentrations to less than 1.0 mg/L; precipitation processes are used for removing toxic heavy metals from electroplating waters; chemical reduction may be used to treat nickel; adsorption has shown potential for treating metal bearing wastes; for liquid wastes, the adsorbed material can be stripped off at high temperatures and burned in an incinerator; store in tightly closed containers in a cool, well-ventilated area; use explosion-proof electrical equipment; separate from acids, and oxidizing materials; keep activated catalyst under inert gas or water.

**REGULATORY INFORMATION: A1.**

**OTHER COMMENTS:** Nickel is extensively used for making stainless steel and other corrosion resistant alloys; used in making desalination plants; nickel added to glass gives green color; component of ferrous and nonferrous alloys, permanent magnets, ceramics, and batteries and fuel cells; used in surgical and dental prostheses; nickel compounds are involved in making tubing of copper-nickel alloy; used in making nickel steel armor plates and burglar proof vaults.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 11; 15; 16; 19.

**NICKEL, SOLUBLE COMPOUNDS** (soluble nickel compounds have variable molecular formulas. The molecular formula for nickel chloride  $\text{NiCl}_2$ ; the molecular formula for nickel sulfate is  $\text{NiSO}_4$ ; Soluble nickel compounds have variable formula weights. The formula weight for nickel chloride is 129.61; the formula weight for nickel sulfate is 154.77).

**CAS/DOT IDENTIFICATION #:** Soluble nickel compounds have variable CAS #'s. The CAS # for nickel is 7440-02-0. The CAS # for nickel chloride is 7718-54-9; the CAS # for nickel sulfate is 7786-81-4./The DOT identification number for nickel is not available. The DOT identification number for nickel chloride is 1378; the identification number of nickel sulfate is 9141.

**SYNONYMS:** (nickel chloride) nickel(2)chloride, nickel (II) chloride, nickel dichloride, nickelous chloride; (nickel sulfate) nickel (2) sulfate, nickel (II) sulfate, nickelous sulfate, sulfuric acid nickel (2) salt.

**PHYSICAL PROPERTIES :** (nickel chloride) yellow or brown scales; nickel chloride hexahydrate appears as green, deliquescent crystals or crystal powder; anhydrous salt is golden yellow; odorless solid; soluble in ethanol and ammonium hydroxide; soluble in water; insoluble in ammonia; MP (1,001°C, 1834°F); DN (3.55 g/cm<sup>3</sup> at 20°C); SG (3.55) VD (NA); VP (1 mmHg at 671°C). (nickel sulfate) yellow cubes; nickel sulfate hexahydrate appears as blue to blue-green tetragonal crystals of green transparent crystals; becomes blue and opaque at room temperature; odorless; soluble in water, ethanol, and methanol; insoluble in alcohol, ether, and acetone; MP (840°C, 1544°F loses  $\text{SO}_3$ ); DN (3.68 g/cm<sup>3</sup> at 20°C); SG (3.68); VD (NA).

**CHEMICAL PROPERTIES:** (nickel chloride) not flammable; sublimes at 973°C; deliquesces; aqueous solution is acidic; (nickel sulfate) not flammable; hexahydrate is stable at 40°C; hexahydrate loses  $5\text{H}_2\text{O}$  at about 100°C; forms yellow anhydrous salt at 280°C; hexahydrate, initially in the alpha form, changes into the beta form at 53.3°C.

**EXPLOSION and FIRE CONCERNS:** (nickel chloride) not flammable; mixture of potassium and nickel chloride produces a strong explosion on impact; decomposition emits very toxic fumes of  $\text{Cl}^-$ ; (nickel sulfate) not flammable; decomposition emits very toxic fumes of ox-

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ides of sulfur; for both nickel chloride and nickel sulfate, use dry powder, dry sand, dry dolomite, or dry graphite for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (allergic asthma, irritates nose, throat and respiratory system); ingestion (vomiting, diarrhea, nausea, headache, giddiness, lassitude, tremors, respiratory problems, death); contact (eye irritation, dermatitis (eczema)).

**HUMAN TOXICITY DATA:** (nickel chloride) no data available in humans; (nickel sulfate) skin-child 5%/48H; sister chromatid exchange-human leukocyte 23 $\mu$ mol/L.

**ACUTE HEALTH RISKS:** (nickel chloride) irritation of nose and throat; vomiting; eye irritation; headache; nausea; insomnia; (nickel sulfate) irritation of eyes, nose and respiratory system; breathing difficulty; decreased pulmonary function; hypersensitivity pneumonitis.

**CHRONIC HEALTH RISKS:** soluble nickel compounds may cause human lung damage and cancer of the lung; increased incidence of cancer of the paranasal sinuses; primary skin eruption may be followed by superficial discrete ulcers, which discharge and become crusted, or by eczema; pigmented or depigmented plaques may be formed in the chronic stages; inhalation of nickel sulfate may cause cutaneous sensitization and the development of apparent asthma; nickel sulfate may also cause infertility in males, mutations in living cells, and lung allergies with wheezing.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg/m<sup>3</sup>; OSHA PEL TWA 1 mg/m<sup>3</sup>; NIOSH REL TWA 0.015 mg/m<sup>3</sup>; IDLH 10 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear effective, impervious clothing, gloves and boots; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb spilled liquid containing nickel in vermiculite, dry sand, or earth; soluble nickel compounds may be disposed of in sealed containers in a secured sanitary landfill; do not allow spilled nickel compounds (especially soluble nickel salts) to run into soil and groundwater.

**DISPOSAL AND STORAGE METHODS:** recycle, if possible; otherwise use hazardous waste disposal site; soluble nickel compounds may be disposed of in tightly sealed containers and secured in a sanitary landfill; store in a cool, dry location; storage should be in tightly closed containers.

**REGULATORY INFORMATION:** (soluble compounds) A1; (nickel chloride) Reportable Quantity (RQ): 100 lbs (45.4 kg); S1; CW1; DOT hazard class/division (NA); labels (NA); (nickel sulfate) Reportable Quantity (RQ): 100 lbs (45.4 kg); S1; CW1; CW2; DOT hazard class/division (NA); labels (NA).

**OTHER COMMENTS:** nickel chloride is used for nickel-plating cast zinc; used in the manufacture of sympathetic ink; anhydrous salt is used as an absorbent for ammonia in gas masks; nickel sulfate is used in nickel-plating; used as a mordant in dyeing and printing fabrics; used in blackening zinc and brass.

**KEY REFERENCES:** 3; 4; 5; 6; 11; 12; 15; 16; 19.

**NICOTINE (C<sub>5</sub>H<sub>4</sub>NC<sub>4</sub>H<sub>7</sub>NCH<sub>3</sub>, 162.26)**

**CAS/DOT IDENTIFICATION #:** 54-11-5/UN1654

**SYNONYMS:** black leaf, 1-methyl-2-(3-pyridyl)pyrrolidine, 3-(1-methyl-2-pyrrolidinyl)pyridine, nicocide, 1-nicotine, tendust.

**PHYSICAL PROPERTIES :** pale-yellow to dark brown liquid; fish-like odor when warm; sharp burning taste; colorless and almost odorless oil in its pure state; becomes viscous on exposure to air; turns brown on exposure to air or light; very hygroscopic; very soluble in alcohol, chloroform, ether, petroleum ether, kerosene, and oils; miscible with water below 60°C; on mixing nicotine with water the volume contracts; MP (-79°C, -110°F); BP (247.3°C, 477°F); DN (1.0097 g/mL at 20°C); LSG (1.01); ST (38.61 dynes/cm at 20°C); VD (5.61); VP (1 mmHg at 61.8°C); OT ( $1.90 \times 10^{-5}$  moles/liter taste detection in water).

**CHEMICAL PROPERTIES:** combustible liquid; will attack some forms of plastics, rubber, and coatings; forms salts with almost any acid; forms double salts with many acids and metals; very volatile with steam; can react with oxidizing materials and acids; FP (95°C, 203°F); LFL/UFL (0.7%, 4.0%); AT (244°C, 471°F); HC (-15.836 Btu/lb, -8.798 cal/g, -368.1  $\times 10^5$  J/kg).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating Health 4, Flammability 1, Reactivity 0; moderately explosive in vapor form; poisonous gases are produced in a fire; reacts vigorously with oxidizing materials; heating to decomposition emits toxic fumes of carbon monoxide and oxides of nitrogen; use alcohol foam, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (burning sensation in mouth and throat, nausea, headache, confusion, visual disturbances); contact (irritates eyes, local irritation of skin); ingestion (burning of mouth and stomach, vomiting, excitement, faintness, paralysis of lungs).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with large amounts of cold water; provide oxygen or respiratory support; if ingested, give 6-8 tablespoons of activated charcoal as a slurry in water.

**HUMAN TOXICITY DATA:** rectal-human TDLo 1430 $\mu$ g/kg; toxic effect: central nervous system, gastrointestinal tract; oral-woman TDLo 40 $\mu$ g/kg (24 weeks pregnant); toxic effect: teratogenic effects; unreported-man LDLo 882 $\mu$ g/kg.

**ACUTE HEALTH RISKS:** burning sensation in mouth and throat; salivation; nausea; abdominal pain; vomiting; diarrhea; headache; sweating; dizziness; auditory disturbances; visual disturbances; confusion; agitation weakness; incoordination; deep and rapid respiration; elevated blood pressure; slow pulse; tremors; convulsions; dilation of pupils; decreased blood pressure; rapid and irregular pulse; faintness; cyanosis; difficulty in breathing; prostration; collapse; death from paralysis of respiratory muscles.

**CHRONIC HEALTH RISKS:** human blood pressure effects; human teratogenic effects; development abnormalities of the cardiovascular system; may alter genetic material; target organs: central nervous system, cardiovascular system, lungs, gastrointestinal tract, reproductive system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.5 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup>(skin); IDLH 5mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing, including boots, sleeves, aprons, etc.; rubber gloves are recommended; wear splash-proof safety goggles and self-contained breathing apparatus.

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**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber equipped with effluent gas cleaning device.

**DISPOSAL AND STORAGE METHODS:** dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; mix into sand-soda ash mixture and burn in incinerator; store in a cool, dry, well ventilated area; keep away from strong oxidizers and acids.

**REGULATORY INFORMATION:** F1; F2; R4; Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf2; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as an insecticide; former use as a greenhouse fumigant; most effective as soap, i.e., as the laurate, oleate, or naphthenate; useful in the treatment of smoking withdrawal syndrome; has been used as an anthelmintic.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 12; 14.

### NITRIC ACID(HNO<sub>3</sub>, 63.02)

**CAS/DOT IDENTIFICATION #:** 7697-37-2/UN2031

**SYNONYMS:** aqua fortis, azotic acid, hydrogen nitrate, red fuming nitric acid, white fuming nitric acid.

**PHYSICAL PROPERTIES :** transparent, colorless or yellowish liquid; fuming nitric acid is reddish fuming liquid; suffocating, choking odor; forms a negative azeotrope (minimum vapor pressure, maximum boiling point) with water; soluble in all proportions in cold and hot water; soluble in ether; frequently used in an aqueous solution; fuming nitric acid is concentrated nitric acid that contains dissolved nitrogen dioxide and yellow brown discoloration; MP (-42°C, -44°F); BP (83°C, 181°F); DN (1.5027 g/mL at 25°C); LSG (1.50); ST (42.7 dynes/cm at 11.6°C); VS (2.275 cP at 0°C, 1.770 cP at 10°C); CP (109.9 J/K-mol liquid at 25°C); HV (39.1 kJ/mol at 25°C); VP (47.8 mmHg at 20°C); OT (0.75 mg/m<sup>3</sup> low, 2.50 mg/m<sup>3</sup> high).

**CHEMICAL PROPERTIES:** strong oxidizer; reacts with water to produce heat; corrosive in presence of traces of oxides; attacks all base metals except aluminum and special chromium steels; reacts vigorously with combustibles, organic solvents, metallic powders, carbides, cyanides, sulfides, or readily oxidizable materials; reacts with alkalis; vigorous reaction caused by addition of water to concentrated nitric acid; FP (NA); LFL/UFL (not combustible); AT (NA); HC (NA); HF (-174.1 kJ/mol liquid at 25°C); H<sub>f</sub> (2.503 kcal/mol); HID (-7971 cal/mol at 25°C).

**EXPLOSION and FIRE CONCERNS:** not flammable; NFPA rating Health 4, Flammability 0, Reactivity 0; contact with combustible materials may increase the hazard from fire and may lead to an explosion; releases hydrogen gas on contact with many metals; poisonous gases are produced when heated; reacts explosively with acetic anhydride, acetone and acetic acid (in storage), acetone and hydrogen peroxide, acetone and sulfuric acid, alcohols, chlorobenzene, cyclohexylamine, and many others; reacts violently with alcohol, turpentine, charcoal, and organic refuse; ignites on contact with acetone, alcohols and disulfuric acid, alcohols and potassium permanganate, aliphatic amines, ammonia, aromatic amines and metal compounds, lead-containing rubber, metals, nonmetal hydrides, and many others; will react with water or steam to produce heat and toxic and corrosive fumes; heating to decomposition emits toxic fumes of ox-

ides of nitrogen and hydrogen nitrate; use water spray or other agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (difficult breathing, loss of consciousness, irritates eyes, nose and throat); contact (severe burns to eyes and skin); ingestion (severe irritation of mouth and stomach).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin immediately with large amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 430 mg/kg; unreported-man LDLo 100mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; corrosive to mucous membranes; delayed pulmonary edema; pneumoniis; bronchitis; drowsiness; unconsciousness.

**CHRONIC HEALTH RISKS:** severe respiratory damage; lung injury; dental erosion; reproductive effects; target organs: eyes, skin, respiratory system, teeth.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm; ACGIH TLV STEL 4 ppm; OSHA PEL TWA 2 ppm ( $5 \text{ mg/m}^3$ ); OSHA PEL STEL 4 ppm ( $10 \text{ mg/m}^3$ ); NIOSH REL TWA 2 ppm ( $5 \text{ mg/m}^3$ ); NIOSH REL STEL 4 ppm ( $10 \text{ mg/m}^3$ ); IDLH 25 ppm.

**PERSONAL PROTECTION:** rubber outer garments and woolen clothing are recommended; wear rubber acid suit, hood, boots and gloves, wear chemical safety goggles and self-contained breathing apparatus; equipment should be resistant to acid vapors; safety shower and eye bath should be provided in the immediate work area.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; flush with large quantities of water and neutralize with alkaline material, such as soda ash or lime; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dilute in cooled quench solution and neutralize with lime or caustic; route to sewage plant; store in a cool, dry location; separate from alkalis, metals, organics, and other oxidizing materials.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 1000 lbs (454kg); Sf1; Sf2; Sf3; CW1; CW2; A1; A5; CAL; DOT hazard class/division (8); labels (corrosive, poison, oxidizer)

**OTHER COMMENTS:** manufacture of inorganic and organic nitrates; used in the manufacture of nitro compounds for fertilizers, dye intermediates, and explosives; useful in the manufacture of pharmaceuticals, jewelry manufacturing and in engineering industry; use as a cauterizing agent for sterilization of badly infected wounds, such as a bite from a rabid animal.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 14.

## **NITRIC OXIDE(NO, 30.01)**

**CAS/DOT IDENTIFICATION #:** 10102-43-9/UN1660

**SYNONYMS:** mononitrogen monoxide, nitrogen monoxide, nitrogen oxide.

**PHYSICAL PROPERTIES :** colorless gas; deep blue when liquid; bluish-white snow when solid; irritating odor; soluble in carbon disulfide and iron sulfate; slightly soluble in

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water; MP (-164°C, 263°F); BP (-151.7°C, -241°F); DN (1.269 g/mL liquid at -150°C); LSG (1.27); VS (19.1  $\mu$ Pa-s at 25°C); CP (29.8 J/K-mol gas at 25°C); HV (13.83 kJ/mol at 121.41 K); VD (1.04); VP (26,000 mmHg at 20°C).

**CHEMICAL PROPERTIES:** nonflammable gas; contains odd number of electrons and is paramagnetic; combines with oxygen to form nitrogen dioxide (NO<sub>2</sub>), a brown gas; combines with chlorine and bromine to form the nitrosyl halides, such as nitrosyl chloride (NOCl); reacts with water to form nitric acid; rapidly converted in air to nitrogen dioxide; reacts with boron, carbon disulfide, chlorine monoxide, chromium, fluorine, fuels, uranium hydrocarbons, nitrogen trichloride, and phosphine; FP (NA); LFL/UFL (NA); AT (NA); HF (-21.5 kcal/mole at 18°C); H<sub>f</sub>(2.3 kJ/mol at 109.5 K).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas, but will accelerate burning of combustible materials; NFPA rating Health 3, Flammability 0, Reactivity 0; strong oxidizer; liquid is a sensitive explosive; reacts explosively with carbon disulfide with emission of light; explosive reaction with methanol, pentacarbonyl iron (at 50°C), phosphine and oxygen, fluorine, perchloryl fluoride (at 100-300°C), and vinyl chloride; mixture with chlorine monoxide can be explosive; explodes on contact with nitrogen trichloride; reacts to form explosive products with heat and corrosive fumes; reacts violently with acetic anhydride, aluminum, barium oxide, calcium, charcoal, 1,2-dichloroethane, dichloroethylene, fuels, hydrocarbons, hydrogen and oxygen, ammonia, trichloroethylene, 1,1,1-trichloroethane, uranium, potassium sulfide, and others, reacts vigorously with reducing materials; will decompose to nitrous acid; use water spray or suitable agent for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (drowsiness, headache, dizziness, formation of methemoglobin, arterial dilation, coughing, shortness of breath, burning in chest and throat, cyanosis, sleeplessness, restlessness, wet skin, loss of consciousness, irritation of eyes, nose and throat).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; irritation of mucous membranes of upper respiratory tract; coughing; burning in the throat and chest; tightness of the chest; shortness of breath; sleeplessness; restlessness; dyspnea; cyanosis; pulmonary edema; drowsiness; loss of consciousness; congestion in the throat and bronchi; arterial dilation; fall in blood pressure; headache, dizziness; methemoglobinemia; death.

**CHRONIC HEALTH RISKS:** chronic irritation of the respiratory tract; cough; headache; loss of appetite; dyspnea; corrosion of the teeth; gradual loss of strength.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm; OSHA PEL TWA 25 ppm (30 mg/m<sup>3</sup>); NIOSH REL TWA 25 ppm (30 mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear full protective clothing including boots, gloves, sleeves, aprons, etc.; wear acid-resistant self-contained breathing apparatus; wear splash-proof safety goggles..

**SPILL CLEAN-UP:** ventilate area of leak; use water spray to disperse vapors; stop flow of gas if possible; if leak cannot be stopped, allow to empty in open air.

**DISPOSAL AND STORAGE METHODS:** cover contaminant with thick layer of soda ash-slaked lime mixture; mix and sift cautiously into large volume of water; neutralize and route

to sewage plant; store in a cool, dry, well-ventilated area; outside storage is preferred; separate from oxidizable materials.

**REGULATORY INFORMATION:** R4; R6; R8; P waste # (P076); Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf2; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas).

**OTHER COMMENTS:** used in the manufacture of nitric acid; used in the preparation of nitrosyl carbonyls; useful as a stabilizer (to prevent free-radical decomposition) for propylene, methyl ether, etc.; also used in the bleaching of rayon.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 14.

### **p-NITROANILINE (NO<sub>2</sub>C<sub>6</sub>H<sub>4</sub>NH<sub>2</sub>, 138.13)**

**CAS/DOT IDENTIFICATION #:** 100-01-6/UN1661

**SYNONYMS:** p-aminonitrobenzene, 1-amino-4-nitrobenzene, 4-nitroaniline, 4-nitrobenzenamine, p-nitrophenylamine, pna.

**PHYSICAL PROPERTIES :** bright-yellow, crystalline powder; slight odor of ammonia; negligible solubility in water; soluble in alcohol, ether, benzene, and methanol; MP (149°C, 300°F); BP (332°C, 630°F); DN (1.424 g/mL at 20°C); LSG (1.42); CP (167.0 J/K-mol crystal at 25°C); VD (4.77); VP (2 x 10<sup>-5</sup> mmHg at 20°C, 1 mmHg at 142°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts vigorously with strong oxidizers, strong reducing agents, acid chlorides, strong acids, and acid anhydrides; forms water soluble salts with mineral acids; FP (199°C, 390°F); LFL/UFL (unknown); AT (unknown); HC (unknown); HF (-42.0 kJ/mol crystal at 25°C); H<sub>f</sub> (21.1 kJ/mol at 420K).

**EXPLOSION and FIRE CONCERNS:** combustible dust; capable of creating a dust explosion; NFPA rating Health 3, Flammability 1, Reactivity 3; sensitive to static discharge; closed containers may rupture violently when heated; moisture causes nitration of organic materials and may result in spontaneous ignition; reacts vigorously with sulfuric acid above 200°C (392°F); may produce explosive sodium-4-nitrophenoxide on reaction with sodium hydroxide under pressure at 130°C (266°F); may decompose explosively in a fire; incompatible with strong oxidizing agents, strong reducing agents, strong acids, strong bases, ketones, alcohols, and aldehydes; hazardous decomposition products include carbon monoxide, carbon dioxide, and oxides of nitrogen; use water, dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, coughing, difficult breathing, dizziness, increased heart rate, cyanosis, nausea, vomiting, unconsciousness); skin absorption (methemoglobinemia (i.e., decreasing oxygen in blood), irritability, drowsiness, stupor, respiratory arrest, muscular incoordination); eye contact (tearing, blurring of vision); ingestion (nausea, vomiting, diarrhea, increased heart rate, bluish discoloration of skin).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and give oxygen; if not breathing, administer artificial respiration; in case of ingestion, induce vomiting immediately and get prompt medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans; does produce genetic damage in bacterial cell cultures but does not produce genetic damage in animals; does not produce heritable genetic damage.

**ACUTE HEALTH RISKS:** irritation of nose and throat; headache; coughing; dizziness; difficult breathing; tachycardia; respiratory arrest; methemoglobinemia; cyanosis (blush discoloration of skin); weakness; irritability; drowsiness; ataxia; nausea; vomiting; diarrhea; unconsciousness; lacrimation; blurring of vision; convulsions.

**CHRONIC HEALTH RISKS:** liver damage, including jaundice; kidney damage; anemia; bone marrow injury; blood damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 3 mg/m<sup>3</sup> (skin); OSHA PEL TWA 1 ppm (6 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 3 mg/m<sup>3</sup> (skin); IDLH 300 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use dust- and splash-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use only in a chemical fume hood; in oxygen-deficient atmospheres, wear positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** with clean shovel, carefully place material into clean, dry container; cover and remove from area; flush remaining spill with large amounts of water and ventilate area.

**DISPOSAL AND STORAGE METHODS:** handle whatever cannot be saved for recovery or recycling as a hazardous waste; send to a RCRA approved incinerator; dispose of container and unused contents in accordance with federal, state and local regulations; store in a well-ventilated area; keep containers tightly closed and dry; store away from incompatible materials; keep away from heated areas, sparks, and flame; protect from freezing.

**REGULATORY INFORMATION:** R3; R4; R5; P waste # (P077); Reportable Quantity (RQ): 5000 lbs (2270 kg); Sf1; Sf3; T30-e10; T120-d10; T799-5025; A1; A5; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a dyestuff intermediate, in particular, p-nitraniline red; other uses include an intermediate for antioxidants, gasoline gum inhibitors, and a corrosion inhibitor.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 14.

## **NITROBENZENE (C<sub>6</sub>H<sub>5</sub>NO<sub>2</sub>, 123.12)**

**CAS/DOT IDENTIFICATION #:** 98-95-3/UN1662

**SYNONYMS:** essence of mirbane, nitrobenzol, NTB, oil of mirbane.

**PHYSICAL PROPERTIES :** greenish-yellow crystals or yellow, oily liquid; odor of volatile oil of almond; pungent, shoe-polish smell; freely soluble in alcohol, benzene, ether, and oils; soluble in acetate; soluble in about 500 parts water; MP (6°C, 42°F); BP (211°C, 411°F); DN (1.205 g/cm<sup>3</sup> at 15°C); SG (1.20); ST (43.9 dynes/cm at 20°C); VS (2.71 cP at 5.94°C, 2.24 cP at 14.94°C, 2.03 cP at 20°C); CP (185.8 J/K-mol); HV (10 Btu/lb, 85 cal/g,

$3.6 \times 10^5$  J/kg); VD (4.25); VP (50 mmHg at 120°C, <1 mmHg at 20°C); OT ( $1.46 \times 10^{-2}$  mg/L vapor).

**CHEMICAL PROPERTIES:** combustible liquid; sublimes at room temperature; reacts with active metals such as tin or zinc; reacts with concentrated nitric acid, nitrogen tetroxide, strong bases, and phosphorus pentachloride; FP (88°C, 190°F); LFL/UFL (1.8%, 40.0%); AT (496°C, 924°F); HC (-5,791 cal/g, -10,420 Btu/lb,  $-242.5 \times 10^5$  J/kg); HF (12.5 kJ/mol liquid at 25°C, 67.5 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 3, Flammability 2, Reactivity 1; moderate explosion hazard; reacts explosively with solid or concentrated sodium hydroxide and heat, potassium hydroxide and heat, aluminum chloride and phenol (at 120°C), sulfuric and nitric acid and heat, and sulfuric acid and aniline and glycerol; violent reaction with aniline and glycerin, silver perchlorate, and dinitrogen oxide; forms explosive mixtures with aluminum chloride, fluorodinitromethane, tetranitromethane, sodium chlorate, nitric acid, nitric acid and water, dinitrogen tetroxide, phosphorus pentachloride, potassium, and sulfuric acid; products of combustion include oxides of nitrogen; use carbon dioxide, dry chemical, foam, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates skin, eyes, and respiratory system); skin absorption (methemoglobinemia, cyanosis); ingestion (general anesthetic, respiratory stimulation, vascular changes).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** unreported-man LDLo 35mg/kg; oral-woman TDLo 200mg/kg; toxic effect: central nervous system, cardiovascular system, pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; headache; nausea; drowsiness; vomiting; cyanosis; anoxia; anemia; methemoglobinemia.

**CHRONIC HEALTH RISKS:** central nervous system disturbances; target organs: blood, liver, kidneys, cardiovascular system, male reproductive system, spleen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm (skin); OSHA PEL TWA 1ppm ( $5\text{mg}/\text{m}^3$ )(skin); NIOSH REL TWA 1ppm ( $5\text{mg}/\text{m}^3$ )(skin); IDLH 200ppm.

**PERSONAL PROTECTION:** wear chemical protective suit with self-contained breathing apparatus; wear chemical resistant rubber gloves; wear splash-proof safety goggles; an eye-wash fountain and safety shower are recommended.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use appropriate foam to blanket release and suppress vapors; absorb small quantities of liquid on paper towels and evaporate in fume hood; allow solid form to melt and cover in noncombustible material for proper disposal; atomize large amounts in a suitable combustion chamber equipped with an effluent gas cleaning device; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid form in noncombustible materials such as dry earth or sand and place in a toxic landfill; dissolve in flammable solvent and burn in incinerator equipped with afterburner and alkaline scrubber; pour onto sodium bicarbonate or sand-soda ash mixture; slurries may be routed to sewers with permission.

**REGULATORY INFORMATION:** CA2; S3; S10; R3; R4; R5; R6; R8; D waste # (D036); U waste # (u169); Reportable Quantity (RQ): 1000lbs (454kg); Sf1; Sf2; Sf3; CW1; CW2; CW3; CW4; CW5; T120-a; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of aniline; used as an ingredient in soaps, shoe polishes, and metal polishes; used as a preservative in spray paints, constituent of floor polishes, and for refining lubricating oils; used in the production of isocyanates, pesticides, rubber chemicals, and acetaminophen.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

### **p-NITROCHLOROBENZENE (C<sub>6</sub>H<sub>4</sub>ClNO<sub>2</sub>, 157.56)**

**CAS/DOT IDENTIFICATION #:** 100-00-5/UN1578

**SYNONYMS:** p-chloronitrobenzene, 4-chloronitrobenzene, 1-chloro-4-nitrobenzene, 4-chloro-1-nitrobenzene, 4-nitrochlorobenzene, pcnb, pncb.

**PHYSICAL PROPERTIES :** pale-yellow crystals; sweet, aromatic odor; insoluble in water; slight solubility in alcohol; very soluble in ether and carbon disulfide; MP (82-84°C, 179.6-183°F); BP (242°C, 467.6°F); DN (1.520 g/cm<sup>3</sup>); SG (1.52); VD (5.44); VP (0.2 mmHg at 86°F).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; reacts with alkalis and oxidizing materials; substance is a strong oxidant and reacts with reducing materials; FP (127°C, 261°F); LFL/UFL (unknown); AT (510°C, 950°F); H<sub>f</sub> (20.8 kJ/mol at 356.6K).

**EXPLOSION and FIRE CONCERNS:** combustible solid; solid does not burn, or burns with difficulty; NFPA rating Health 3, Flammability 1, Reactivity 2; finely dispersed particles form explosive mixtures in air; reacts with many substances causing fire and explosion hazard; may explode on heating; reacts violently with sodium methoxide and other combustible and reducing materials; decomposes on heating, producing toxic fumes of hydrochloric acid, phosphene, chlorine, and oxides of nitrogen; use powder, water spray, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, vertigo, faintness, weakness, bluish discoloration of skin, anoxia, irritates eyes, skin and respiratory system); skin absorption (skin sensitization, other symptoms parallel those of inhalation); ingestion (anemia, formation of methemoglobin, unpleasant taste, other symptoms parallel those of inhalation).

**FIRST AID:** wash eyes with water for several minutes; promptly wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; in case of ingestion, rinse mouth and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to eyes, skin and respiratory system; headache; faintness; vertigo; weakness; cyanosis; pulmonary edema; anoxia; unpleasant tastes; may cause effects on the blood.

**CHRONIC HEALTH RISKS:** prolonged contact may cause skin sensitization; may have effects on the blood, including anemia and methemoglobinemia; based on animal tests, may result in hemoglobinuria, hematuria (blood in urine), and injury to spleen, kidney and bone marrow; may possibly cause reproductive effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (0.64 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 1 mg/m<sup>3</sup>(skin); NIOSH REL TWA lowest feasible concentration (skin); IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection if powder; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing protection apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** stop or control leak if possible; cover spill with noncombustible material for proper disposal; sweep spilled substance into sealable containers; collect remaining materials, then remove to a safe place.

**DISPOSAL AND STORAGE METHODS:** cover spill with noncombustible material, and place in a secured, sanitary landfill; dispose of in accordance with federal, state and local regulations; store in a cool, dry location; keep in a well-ventilated room; separate from combustible and reducing substances, food and feedstuffs.

**REGULATORY INFORMATION:** T30-e10; T120-d10; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a chemical intermediate, especially in the preparation of dyes, agricultural chemicals, and rubber chemicals; useful in the manufacture of p-nitrophenol, from which parathion is made.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 10; 14.

**4-NITRODIPHENYL** (C<sub>12</sub>H<sub>9</sub>NO<sub>2</sub>, 199.22).

**CAS/DOT IDENTIFICATION #:** 92-93-3/none

**SYNONYMS:** p-nitrobiphenyl, 4-nitrobiphenyl, p-nitrodiphenyl, p-phenyl-nitrobenzene, 4-phenyl-nitrobenzene, pnb.

**PHYSICAL PROPERTIES:** white to light yellow, needle-like, crystalline solid; sweet odor; insoluble in water; readily soluble in hot alcohol, but slightly soluble in cold alcohol; very soluble in ether; soluble in chloroform, carbon tetrachloride, benzene, acetone, mineral spirits, turpentine, glacial acetic acid, pine oil, and perchloroethylene; MP(113-114°C, 235.4-237.2°F); BP(340°C, 644°F at 760 mmHg, 223.7-224.1°C, 434.7-435.4°F at 30 mmHg); DN(1.203 g/cm<sup>3</sup> at 25°C); VD(not applicable); VP(unknown).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with strong reducing agents; FP(143°C, 290°F); LFL/UFL (unknown); AT (180°C, 356°F).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating (not rated); contact with strong oxidizers may cause fire and explosion; incompatible with strong reducers; heating to decomposition emits toxic fumes of oxides of nitrogen; use dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, shortness of breath); skin absorption (weakness, lethargic feeling, muscle incoordination); ingestion (urinary burning, formation of methemoglobin, hemorrhagic cystitis).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes, skin, and respiratory tract; headache; dizziness; lethargy; dyspnea; ataxia; urinary burning; acute hemorrhagic cystitis; weakness; methemoglobinemia.

**CHRONIC HEALTH RISKS:** mutation data has been reported; confirmed carcinogen based on experimental carcinogenic, neoplastigenic, and tumorigenic data.

**EXPOSURE GUIDELINES:** ACGIH TLV confirmed human carcinogen; OSHA PEL TWA cancer suspect agent (use 1910.1003); NIOSH REL TWA potential occupational carcinogen; IDLH (not determined) potential occupational carcinogen.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, apron, elastic sleeves and disposable coveralls; wear dust-proof safety goggles; enclose operations above 143°C and/or use local exhaust ventilation at site of chemical release; wear any self-contained breathing apparatus that has a full facepiece and is operated in positive-pressure mode; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; cover spill with dry lime or soda ash, and deposit in sealable containers; wash remaining spill with plenty of water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; use only with adequate ventilation; separate from strong reducing agents and strong oxidizers.

**REGULATORY INFORMATION:** CA2; Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf3; A1; A4; CAL; DOT classification (none).

**OTHER COMMENTS:** used as a dye intermediate; used as a component or in the manufacture of fungicides, wood preservatives, and plasticizers for cellulosic materials; formerly used in the preparation of p-biphenyl amine; not manufactured, imported, used, or sold in the United States at the present time.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 19.

**NITROETHANE** (CH<sub>3</sub>CH<sub>2</sub>NO<sub>2</sub>, 75.08).

**CAS/DOT IDENTIFICATION #:** 79-24-3/UN2842

**SYNONYMS:** nitroetan

**PHYSICAL PROPERTIES:** oily, colorless liquid; mild, fruity odor; moderate solubility in hot water; insoluble in cold water; miscible in methanol, ethanol, diethyl ether, and chloroform; soluble in aqueous solutions of alkalis; MP(-90°C, -130°F); BP(114°C, 237°F); DN(1.052 g/mL at 20°C); LSG(1.05); ST (32.13 mN/m at 25°C) VS(0.661 cP at 25°C); CP (134.4 J/k-mol liquid at 25°C); HV(41.59 kJ/mol at 25°C); VD(2.58); REL DN vapor/air mixture (1.03 at 20°C); VP(15.6 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; substance is a strong reducing agent and reacts with oxidants; reacts with many strong alkalis; may attack some forms of plastic; incompatible with calcium hydroxide, potassium hydroxide, sodium hydroxide, hydrocarbons, metal oxides, and inorganic bases; undergoes thermal decomposition at 335-382°C (635-719.6°F); heating value is reported to be 7,720 Btu/lb liquid; FP(28°C, 82°F); LFL/UFL (3.4%, unknown); AT (414°C, 778°F) HF(-143.9 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 1, Flammability 2, Reactivity 3; explosive vapor/air mixtures may be formed above 28°C; flash-back along vapor trail may occur; closed containers may explode on heating; forms shock-sensitive compounds with strong alkalis, acids, or combination of amines and heavy metal oxides; reacts vigorously with strong oxidants; flames may result due to sudden absorption of the anhydrous liquid or gas on activated carbon; hazardous decomposition products include carbon monoxide, carbon dioxide and oxides of nitrogen; use dry chemical foam, carbon dioxide, or flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, headache, irritates eyes, skin, and respiratory tract); contact (injures liver and kidneys, dermatitis); ingestion (sore throat, abdominal pain).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, give oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, rinse mouth and seek medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory tract; cough; headache; abdominal pains; sore throat; lowering of consciousness; based on testing in animals, may cause lacrimation, dyspnea, pulmonary edema, narcosis, and injury to liver and kidneys.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact may cause dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV 100 ppm (307 mg/m<sup>3</sup>); OSHA PEL TWA; 100 ppm (310 mg/m<sup>3</sup>) (skin); NIOSH REL TWA 100 ppm (310 mg/m<sup>3</sup>); IDLH (1000 ppm).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; use water spray to cool and disperse vapors; collect leaking liquid in sealable containers or absorb in sand or inert absorbent; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and place in sanitary landfill; store in a cool, dry location; maintain adequate ventilation, detached storage is preferred; inside storage should be in a standard flammable liquids storage room or cabinet; separate from combustible and reducing substances.

**REGULATORY INFORMATION:** T120-a; A1; CAL; DOT /division (3); label (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose acetate, nitrocellulose, cellulose acetate butyrate, cellulose acetate propionate, waxes, fats, dyestuffs, and vinyl or alkyd resins; used in organic synthesis, for example, Friedel-Crafts synthesis; has been used experimentally in propellant research.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 14.

### **NITROGEN DIOXIDE (NO<sub>2</sub>, 46.01)**

**CAS/DOT IDENTIFICATION #:** 10102-44-0/UN1067

**SYNONYMS:** nitrogen peroxide, nitrogen tetroxide.

**PHYSICAL PROPERTIES :** yellowish-brown liquid or reddish-brown gas (above 70°F); in solid form (below 15°F) may appear as white to bluish-white snow; pungent, irritating odor; soluble in concentrated sulfuric acid and nitric acids; soluble in alkalis, chloroform, and carbon disulfide; commercial brown liquid under pressure is an equilibrium mixture of nitrogen dioxide and the colorless N<sub>2</sub>O<sub>4</sub>; MP (-9°C, 15°F); BP (21°C, 70°F); DN (1.448 g/mL liquid at 20°C); LSG (1.44 at 68°F); HV (9.110 kcal/mol); VD (1.58); VP (400 mmHg at 80°C); OT (4 ppm).

**CHEMICAL PROPERTIES:** noncombustible liquid/gas; strong oxidizer; corrosive to steel when wet; reacts with alkalis to form nitrates and nitrites; decomposes in water forming nitric acid and nitric oxide; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); T<sub>c</sub> (158.2°C); P<sub>c</sub>(99.96 atm).

**EXPLOSION and FIRE CONCERNS:** not flammable; NFPA rating Health 3, Flammability 0, Reactivity 1; enhances combustion of organic matter and other combustible materials; reacts violently with cyclohexane, fluorine, formaldehyde, and alcohols; violent reaction with nitrobenzene, petroleum and toluene; poisonous gases may be produced in fire; decomposition emits toxic fumes of oxides of nitrogen; use water spray or other suitable agent for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, dyspnea, pulmonary changes, choking, chest pain, cyanosis, mental confusion, irritation of eyes, nose and throat); contact (mild irritation of skin and eyes); ingestion (nausea, pain in abdomen).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with copious amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 200ppm/1M; inhalation-man TCLo 6200ppb/10M; toxic effect: pulmonary system; inhalation-man TCLo 90 ppm/40M; toxic effect: pulmonary system.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; pulmonary edema; coughing; choking headache; nausea; pain in chest and abdomen; fatigue; restlessness; difficulty in breathing; mucoid frothy sputum; mental confusion; lethargy; bluish skin; weak, rapid pulse; unconsciousness; death by asphyxiation.

**CHRONIC HEALTH RISKS:** pulmonary vascular resistance changes; chronic bronchitis; reproductive effects; target organs: eyes, respiratory system, cardiovascular system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 3 ppm; ACGIH TLV STEL 5 ppm; OSHA PEL STEL 1 ppm; OSHA PEL CL 5 ppm (9 mg/m<sup>3</sup>); NIOSH REL STEL 1 ppm (1.8 mg/m<sup>3</sup>); IDLH 20 ppm.

**PERSONAL PROTECTION:** wear full gas-tight clothing or rubber overclothing; rubber gloves are recommended; wear chemical safety goggles and self-contained breathing apparatus; equipment should be resistant to nitric acid corrosion.

**SPILL CLEAN-UP:** if in gaseous form, stop flow of gas if possible; if leak cannot be stopped, allow gas to empty in a safe place in the open air; use water spray to cool and disperse vapors; if in the liquid form, allow to vaporize.

**DISPOSAL AND STORAGE METHODS:** cover with thick layer of 50-50 mixture of soda ash-slaked lime; mix and spray water continuously with an atomizer; neutralize and route to sewage plant; store in a cool, dry location; outside storage is preferred; may be stored in steel cylinders when moisture content is 0.1% or less; separate from oxidizable materials.

**REGULATORY INFORMATION:** R4; P waste # (P078); Reportable Quantity (RQ): 10 lbs (4.54kg); Sf1; Sf2; CW1; CW2; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, oxidizer)

**OTHER COMMENTS:** has been used to bleach flour; proposed as an oxidizing agent for rocket fuels; intermediate in nitric and sulfuric acid production; used in the nitration of organic compounds and explosives; useful in the manufacture of oxidized cellulose compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 13; 14.

## **NITROGEN TRIFLUORIDE (NF<sub>3</sub>, 71.01)**

**CAS/DOT IDENTIFICATION #:** 7783-54-2/UN2451

**SYNONYMS:** nitrogen fluoride, perfluoroammonia, trifluoroamine, trifluoroammonia.

**PHYSICAL PROPERTIES :** colorless gas; low level impurities may impart pungent, moldy odor; slightly soluble in water; will not hydrolyze; MP (-208.5°C, -343.3°F); BP (-129°C, -200.2°F); DN (1.537 g/mL liquid at -129°C); CP (53.4 J/K-mol gas at 25°C); HV (11.56 kJ/mol at 144.40K); VD (0.1843); VP (>1 atm at 20°C); OT (odor warning when exposure limit value is exceeded is insufficient).

**CHEMICAL PROPERTIES:** generally stable; rather inert chemically; hazardous polymerization will not occur; temperatures >400°F, including temperatures produced through adiabatic compression, heat, and flames will contribute to its instability; does not attack glass or mercury at normal temperatures; a very strong oxidant; reacts with combustible and reducing materials FP (NA); LFL/UFL (NA); AT (NA); HF(-132.1 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; NFPA rating (NA); not combustible but enhances combustion of other substances; very dangerous fire hazard; severe explosion hazard by chemical reaction with reducing agents, particularly when under pressure; cylinders may vent rapidly or explode upon exposure to intense heat or flame; can react and ignite with metals and non-metallic materials; reacts violently with ammonia, carbon monoxide, diborane, hydrogen, hydrogen sulfide, methane or tetrafluorohydrazine, causing explosion hazard; hazardous under pressure; incompatible with oil, grease, charcoal, and hydrogen-containing compounds; heating to decomposition emits toxic fluoride compounds including hydrogen fluoride; all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (reduction of blood's ability to transport oxygen, destruction of red blood cells, weakness, dizziness, confusion, headache, injury to the liver and kidneys, irritates eyes, skin, respiratory and gastrointestinal tracts).

**FIRST AID:** wash eyes immediately with large amounts of water; rinse skin with water; remove contaminated clothes and rinse again; move to uncontaminated area and fresh air; provide oxygen or respiratory support if necessary; specific treatment, including oxygen and methylene blue exchange transfusions, may be required.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** headache, weakness; dizziness; cyanosis; inhibition of oxygen transport in blood due to the conversion of hemoglobin to methemoglobin; destruction of red blood cells; irritation of eyes; confusion.

**CHRONIC HEALTH RISKS:** impaired kidney function; injury to the liver; anemia; skeletal changes; mottling of teeth.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm; OSHA PEL TWA 10 ppm (29 mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (29 mg/m<sup>3</sup>); IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, including leather welder's jacket, leather gloves, and safety shoes; chemical safety goggles and face shield are recommended; use positive pressure self-contained breathing apparatus in high vapor concentrations; local exhaust ventilation should be provided to prevent accumulation of material concentrations above 10 ppm.

**SPILL CLEAN-UP:** stop flow of gas if possible; large releases may require down wind evacuation; if leak in user's system, close valve, vent and purge lines with inert gas before repairs; increase ventilation.

**DISPOSAL AND STORAGE METHODS:** return cylinder and unused product to supplier; do not attempt to dispose of unused product; store upright in a cool, well-ventilated area; fireproof if in building; storage should be in temperatures <125°F away from combustibles, salt, and other corrosives.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (2.2); labels (nonflammable gas, oxidizer).

**OTHER COMMENTS:** used as an oxidizer for high-energy fuels; useful in chemical synthesis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **NTIROGLYCERIN (C<sub>3</sub>H<sub>5</sub>N<sub>3</sub>O<sub>9</sub>, 227.11)**

**CAS/DOT IDENTIFICATION #:** 55-63-0/UN0143 (Desensitized)

**SYNONYMS:** blasting oil, glyceryl trinitrate, ng, nitric acid triester of glycerol, 1,2,3-propanetriol trinitrate, trinitroglycerin.

**PHYSICAL PROPERTIES :** colorless to yellow liquid or pale yellow crystals; viscous liquid; sweet burning taste; miscible with ether, acetone, glacial acetic acid, ethyl acetate, pyridine, chloroform, ethylene bromide, benzene, nitrobenzene, and dichloroethylene; sparingly soluble in petroleum ether, glycerol and liquid petrolatum; practically insoluble in water; MP

(13°C, 55°F); BP (explodes at 218°C, 424°F); DN (1.599 g/mL at 15°C); LSG(1.6); VD (7.8); VP (1 mmHg at 127°C).

**CHEMICAL PROPERTIES:** explosive liquid; appreciably volatile at 100°C (212°F); begins to decompose at 50-60°C (122-140°F); evolves nitrous yellow vapors at 135°C (275°F); explodes at 218°C (424°F); reacts with ozone causing an explosion hazard; harmless gases are produced on explosion; FP (explodes); LFL/UFL (NA); AT (270°C, 518°F); HF (-370.9 kJ/mol liquid at 25°C); HC (1580 cal/g); H<sub>f</sub> (21.9 kJ/mol at 286K).

**EXPLOSION and FIRE CONCERNS:** very dangerous fire hazard; NFPA rating Health 2, Flammability 2, Reactivity 4; severe explosion risk on rapid heating or on concussion; very sensitive to mechanical shock, heat or UV radiation; small quantities can readily be detonated by a hammer blow on a hard surface, particularly when absorbed in filter paper; liquid nitroglycerin is somewhat more sensitive than the frozen form; half-thawed or partially thawed mixture is more sensitive than either one; reacts with ozone causing explosion hazard; incompatible with shock, friction, heat, and acids; an OSHA class A explosive; on combustion, forms toxic fumes including oxides of nitrogen; use water spray, foam, carbon dioxide, or powder for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (throbbing headache, dizziness, difficult breathing, bluish discoloration of skin and fingernails); skin absorption (mental confusion, excitement, vertigo, fainting, palpitations, circulatory collapse, hypotension); ingestion (nausea, vomiting, abdominal cramps); skin/eye contact (redness, pain, skin sensitization); intravenous (encephalitis, miosis, corneal damage).

**FIRST AID:** rinse eyes with plenty of water for several minutes; wash affected areas of skin with large amounts of soap and water; provide oxygen or respiratory support; if ingested, rinse mouth and get immediate medical attention.

**HUMAN TOXICITY DATA:** intravenous-man TDLo 51,249µg/kg/2D-intermittent; toxic effect: central nervous system, eye.

**ACUTE HEALTH RISKS:** abdominal cramps, nausea; vomiting; blue lips or fingernails; blue skin; dizziness; headache; mental confusion; delirium; bradypnea; bradycardia; methemoglobinemia; paralysis; convulsions; circulatory collapse; reduced blood pressure; vertigo; fainting; respiratory rales; death.

**CHRONIC HEALTH RISKS:** severe headache; hallucinations; skin rashes; angina.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05ppmv(0.46 mg/m<sup>3</sup>)(skin); OSHA PEL CL 0.2ppm (2 mg/m<sup>3</sup>)(skin); NIOSH REL STEL 0.1mg/m<sup>3</sup>(skin); IDLH 75 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear fireproof clothing and protective gloves; use face shield or eye protection in combination with breathing protection; use non-sparking handtools and explosion-proof electrical equipment and lighting.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers; absorb remaining liquid in noncombustible materials such as dry earth, sand or other inert absorbent, and remove to safe place; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent and place in a secured sanitary landfill; flush remaining liquid with large amounts of water but not into spaces such as sewers because of danger of explosion; fireproof storage area; store only if stabilized; separate from food and feedstuffs; keep away from open flames, sparks, and contact with hot surfaces.

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**REGULATORY INFORMATION:** R4; P waste # (P081); Reportable Quantity (RQ): 10 lbs (4.54kg); Sfl; Sf3; A1; CAL; DOT hazard class/division (1.1D); labels (explosive 1.1D, poison).

**OTHER COMMENTS:** explosive ingredient in dynamite (20-40%) with ethylene glycol dinitrate (80-60%); used as a vasodilator (coronary) and in antianginal medication; also used in rocket propellants; useful in combating fires in oil wells.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### MANGANESE COMPOUNDS (Mn, 54.94)

**CAS/DOT IDENTIFICATION #:** 7439-96-5/NA

**SYNONYMS:** colloidal manganese, mangacat manganese-55.

**PHYSICAL PROPERTIES :** steel gray metal; lustrous, hard, brittle metal; exists in four allotropic forms:  $\alpha$ -form (body-centered cubic),  $\beta$ -form (cubic),  $\gamma$ -form (face-centered cubic), and  $\delta$ -form (body-centered cubic); solids do not evaporate; small dust particles can become suspended in air; MP(1244°C, 2271°F); BP(2060°C, 3740°F); DN(7.20 g/cm<sup>3</sup> at 20°C); SG(7.20); CP(0.115 cal/g/°C); VP(1 mmHg at 1292°C); Mohs' hardness 5.0.

**CHEMICAL PROPERTIES:** superficially oxidized on exposure to air; burns with an intense white light when heated in air; reacts with water or steam to produce hydrogen; reacts with aqueous solutions of sodium or potassium bicarbonate reacts with diluted mineral acids with formation of divalent manganous salts and evolution of hydrogen; powder form reduces most metallic oxides on heating; reacts directly with carbon, phosphorous, antimony, or arsenic on heating; LH<sub>f</sub> (3.5 kcal/g-atom).

**EXPLOSION and FIRE CONCERNS:** flammable and moderately explosive in the form of dust or powder on exposure to heat or flame; NFPA rating (not available); dust may explode when heated in carbon dioxide; powdered metal ignites on contact with fluorine, chlorine + heat, sulfur dioxide + heat, hydrogen peroxide, and bromine pentafluoride; reacts violently with nitrogen dioxide and oxidants; incandescent reaction with phosphorous, nitric acid, and nitril fluoride; reaction with water or steam produces hydrogen; mixtures of aluminum dust and manganese dust may explode in air; mixtures with ammonium nitrate may explode on heating; use special dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, vomiting, nausea, abdominal pain); skin absorption (pulmonary damage, central nervous system damage); contact (eye irritation, skin irritation, vesiculation).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man TCl<sub>o</sub> 2300 µg/m<sup>3</sup>; toxic effect: brain, central nervous system.

**ACUTE HEALTH RISKS:** no information is available on the acute effects in humans; development of symptoms usually take from 1 to 3 years.

**CHRONIC HEALTH RISKS:** Parkinsonism; multiple sclerosis; amyotrophic lateral sclerosis; mental confusion; central nervous system effects; speech disturbances; tremors; psychological disturbances; speak with slow monotonous voice; muscular twitching; nocturnal

cramps of legs; increased incidence of cough; bronchitis; increased susceptibility to lung disease; increased risk of pneumonia; sleepiness; impotence and increased risk of pneumonia; sleepiness impotence and loss of libido in men; increased risk of sterility; mask-like face; weakness; lethargy; metal fume fever: dry throat, coughing, tight chest, breathing difficulty, flu-like fever; lower back pain; vomiting; malaise; fatigue; kidney damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (dust and compounds) 5 mg/m<sup>3</sup>; ACGIH TLV STEL (fume) 3 mg/m<sup>3</sup>; ACGIH TLV (fume) 1 mg/m<sup>3</sup>; OSHA PEL TWA (fume) 1 mg/m<sup>3</sup>; OSHA PEL STEL (fume) 3 mg/m<sup>3</sup>; OSHA PEL (dust and compounds) 5 mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; NIOSH REL STEL 3 mg/m<sup>3</sup>; IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear self-contained breathing apparatus; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use dust explosion-proof electrical equipment and lighting; for extra personal protection, use a P2 filter respirator for harmful particles; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep spilled substance into containers; collect remaining material, then remove to a safe place; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substance into containers and dispose of in a secured, sanitary landfill; store in a cool, dry location; use only with adequate ventilation; separate from acids..

**REGULATORY INFORMATION:** CA2; A1.

**OTHER COMMENTS:** use as a constituent for several alloys, including ferromanganese and copper manganese; use in the production of steel; used for rock crushers and railway points and crossings

**KEY REFERENCES:** 3; 4; 5; 6; 7; 13; 14; 19.

## 1-NITROPROPANE (C<sub>3</sub>H<sub>7</sub>NO<sub>2</sub>, 89.1)

**CAS/DOT IDENTIFICATION #:** 108-03-2/UN2608

**SYNONYMS:** nitropropane, 1-NP.

**PHYSICAL PROPERTIES :** colorless, oily liquid; disagreeable odor; miscible with alcohol, ether, and many organic solvents; MP (-108°C, -162°F); BP (132°C, 269.6°F); DN (1.003 g/mL at 20°C); LSG (1.00); HV (10.37 kcal/mole at 25°C); VD (3.06); VP (7.5 mmHg at 20°C).

**CHEMICAL PROPERTIES:** reacts with amines, strong acids, alkalis, strong oxidizing agents, hydrocarbons, and other combustible materials; reacts with metal oxides; FP (34°C, 93°F); LFL/UFL(2.2%, NA); AT (420.6°C, 789°F); HC (481.33 kcal/mol at 25°C); HF (-40.00 kcal/mol at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 1; very dangerous fire hazard; containers may explode in fire; vapor may explode if ignited in enclosed area; flashback along vapor trail may occur; violent reaction with calcium hydroxide, hydrocarbons, hydroxides, and inorganic bases; may ignite on contact

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with metal oxides; decomposition emits toxic fumes of oxides of nitrogen; use dry chemical, water spray, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, headache, dizziness, coughing, nausea, dyspnea); ingestion (vomiting, diarrhea).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** eye-human 150ppm/15M; inhalation-human TCLo 150 ppm; toxic effect: eye.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; headache; nausea; vomiting; diarrhea; anoxia; kidney damage; severe damage to the liver.

**CHRONIC HEALTH RISKS:** anorexia; nausea; vomiting; severe headaches; methemoglobinemia; cyanosis; pulmonary irritation; liver effects; hypermotility; possible cancer hazard; target organs: eyes, liver, kidneys, central nervous system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2.5ppm; OSHA PEL TWA 25ppm (90 mg/m<sup>3</sup>); NIOSH REL TWA 25ppm (90mg/m<sup>3</sup>); IDLH 1000ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; cover spills with soda ash, spray with water, and neutralize with hydrochloric acid; route to sewage plant; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; cautiously ignite small amounts in open areas; atomize large amounts in a suitable combustion chamber with afterburner and scrubber; store in a cool, dry place; store in closed containers with adequate ventilation; keep away from heat, sparks, and flame; separate from acids, amines, alkalies, oxidizers, metal oxides, and combustibles; outside storage preferred.

**REGULATORY INFORMATION:** T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as an intermediate in the synthesis of pharmaceuticals, dyes, and insecticides; used to provide better flow characteristics and film integrity; used to increase wetting ability and electrostatic spraying properties; used to ensure greater pigment dispersion; used as a solvent in vinyl and epoxy coatings, nitrocellulose, chlorinated rubbers, printing inks, and adhesives.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 12; 13; 14.

### 2-NITROPROPANE (C<sub>3</sub>H<sub>7</sub>NO<sub>2</sub>, 89.1)

**CAS/DOT IDENTIFICATION #:** 79-46-9/UN2608

**SYNONYMS:** dimethylnitromethane, isonitropropane, nitroisopropane, 2-NP.

**PHYSICAL PROPERTIES :** colorless liquid; pleasant, fruity odor; soluble in chloroform; miscible with ketones, esters, most ethers, most aromatic hydrocarbons, and the lower

carboxylic acids; slightly soluble in water; MP (-93°C, -135.4°F); BP (120.3°C, 248.5°F); DN (0.9821 g/mL at 25°C); LSG (0.98); ST (30 dynes/cm at 20°C); CP (170.3 J/K-mol liquid at 25°C); HV (9.88 kcal/mole at 25°C); VD (3.06); VP (10 mmHg at 15.8°C, 20 mmHg at 25°C); OT(2.49 x 10<sup>4</sup> ppb).

**CHEMICAL PROPERTIES:** will not polymerize; reacts with strong acids, alkalies, amines, oxidizers, and metal oxides; reacts with combustible materials; FP (28°C, 82°F); LFL/UFL(2.6%, 11.0%); AT (428°C, 802°F); HC (477.60 kcal/mol at 25°C); HF (-43.78 kcal/mol at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 2; very dangerous fire hazard; may explode on heating; vapors may flashback along vapor trail; closed containers may rupture violently on heating; reacts with chlorosulfonic acid and oleum; reaction with amines and heavy metal oxides forms explosive salts; ignites on contact with mixtures of carbon and hopcalite; may decompose explosively; combustion by-products include oxides of nitrogen and toxic gases; use water spray, dry chemical foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, coughing, breathing difficulty, irritates eyes and skin); ingestion (nausea, vomiting).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man TCLo 20ppm; toxic effect: central nervous system, gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; headache; nausea; vomiting; diarrhea; anorexia; anoxia; kidney damage; severe liver damage.

**CHRONIC HEALTH RISKS:** hypermotility; liver effects; pulmonary irritation; methemoglobinemia; cyanosis; nausea; vomiting; diarrhea; severe headaches; anorexia; possible cancer hazard; EPA Group 2B: probably human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm; OSHA PEL TWA 25ppm (90 mg/m<sup>3</sup>); NIOSH REL TWA reduce to lowest feasible level; IDLH 100ppm.

**PERSONAL PROTECTION:** wear full protective clothing and chemical-resistant gloves; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; cover spills with soda ash and spray with water; neutralize with hydrochloric acid and pass into drain with sufficient amounts of water; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** pour over soda ash, mix and spray with water into large tank; neutralize with hydrochloric acid and pass to sewage plant; absorb in non-combustible materials such as dry earth, sand or vermiculite; burn in incinerator equipped with afterburner and scrubber; store in a cool, dry place; storage should be in closed containers with adequate ventilation; keep away from heat, sparks, and flame; separate from acids, alkalies, amines, oxidizers, metal oxides, and combustibles; outside storage preferred.

**REGULATORY INFORMATION** CA2; S10; R4; R7; U waste # (U171); Sf1; Sf3; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for cellulose acetate, vinyl resins, lacquers, synthetic rubbers, fats, oils, and dyes; used in the manufacture of explosives, rocket propellants, and racing car fuels; used as an additive in gasoline and a smoke depressant in diesel fuel.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

### **N-NITROSODIMETHYLAMINE ((CH<sub>3</sub>)<sub>2</sub>N<sub>2</sub>O, 74.10)**

**CAS/DOT IDENTIFICATION #:** none/none

**SYNONYMS:** dimethylnitrosamine, n,n-dimethylnitrosamine, dmna, n-methyl-n-nitrosomethanamine, ndma, n-nitroso-n,n-dimethylamine.

**PHYSICAL PROPERTIES :** yellow, oily liquid; no appreciable odor; very soluble in water, alcohol, and ether; soluble in all common organic solvents, including lipids; miscible with methylene chloride and vegetable oils; MP(unknown); BP(151-153°C, 304-307°F); DN(1.0048 g/cm<sup>3</sup> at 20°C); SG (1.005); VS (low); VP(2.7 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under normal temperatures and pressures; stable at room temperature in neutral and alkaline solution in the dark for more than fourteen days; slightly less stability in acidic solutions; sensitive to ultraviolet light; photochemically reactive; hazardous polymerization has not been reported; may be oxidized to nitramine or reduced to the hydrazine or amine; has shown resistance to hydrolysis; FP (61°C, 141.8°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating (not published); very dangerous; violent decomposition will occur under some disastrous conditions; emits toxic fumes of oxides of nitrogen under fire conditions; incompatible with strong oxidizing agents; use water, dry chemical, chemical foam, carbon dioxide, or alcohol-resistant foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, nausea, vomiting, irritates eyes, skin, and upper respiratory tract); skin absorption (symptoms parallel those of inhalation); ingestion (abdominal cramps, nausea, vomiting, diarrhea, jaundice, gastrointestinal hemorrhage).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if breathing has stopped, provide respiratory support; in case of ingestion, rinse mouth and then drink 2-4 cupfuls of water; seek medical advice.

**HUMAN TOXICITY DATA:** mutation in mammalian somatic cells (msc) – human lymphocyte 14 mmol/L; oral-woman LDLo 20 mg/kg/2.5Y; toxic effect: gastrointestinal tract; ACGIH: A3- animal carcinogen; California: carcinogen-initial date 10/1/87; NIOSH: occupational carcinogen; OSHA: possible select carcinogen; IARC: Group 2A carcinogen.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory tract; irritation to tissues of mucous membranes; headache; fever; weakness; dizziness; abdominal cramps; nausea; vomiting; diarrhea; gastrointestinal hemorrhage; enlarged liver; jaundice.

**CHRONIC HEALTH RISKS:** has caused fatal liver disease in humans; decreased liver, kidney, and pulmonary function; may alter genetic material.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA suspected human carcinogen; OSHA PEL [1910.1016] cancer suspect agent; NIOSH REL suspected occupational carcinogen; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including rubber boots, heavy rubber gloves, lab coat, rubber apron or coveralls; wear chemical safety goggles if splashing is possible; use adequate local exhaust ventilation to keep airborne concentrations below permissible exposure limits; wear self-contained breathing apparatus; maintain eyewash baths and safety showers in general work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; absorb spill with inert material (e.g., dry earth, sand, vermiculite), then place into a container; after absorbent has been picked up, surface should be thoroughly cleaned with strong detergent solution.

**DISPOSAL AND STORAGE METHODS:** absorb material with sand or inert absorbent, and place in a secured, sanitary landfill; dissolve material with combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber; dispose of in accordance with federal, state, and local regulations; store in a cool, dry place; use only with adequate ventilation; keep containers tightly closed; should be stored in dark bottles; separate from strong oxidizing agents.

**REGULATORY INFORMATION:** CA2; R3; R4; R5; R7; R8; P waste # (P082); Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf1; Sf2; Sf3; CW4; CW5; A1; A4; CAL.

**OTHER COMMENTS:** used as a solvent in fiber and plastics industry; chemical intermediate in the preparation of thiocarbonyl fluoride polymers and in the plasticization of rubber; formerly used in the manufacture of 1,1-dimethylhydrazine for rocket propellants; presently used for research purposes.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 14.

### **o-NITROTOLUENE (NO<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CH<sub>3</sub>, 137.15)**

**CAS/DOT IDENTIFICATION #:** 88-72-2/UN1664

**SYNONYMS:** 2-methylnitrobenzene, o-methylnitrobenzene, 2-nitrotoluene, orto-nitrotoluene, ont.

**PHYSICAL PROPERTIES :** yellowish oily liquid at ordinary temperature; solid below 25°F; weak, aromatic odor; miscible in alcohol, benzene, and ether; soluble in sulfur dioxide and petroleum ether; slightly soluble in ammonia; insoluble in water; MP (-9°C, 15°F); BP (222°C, 432°F); DN (1.1622 g/cm<sup>3</sup> at 19°C); LSG (1.16); VD (4.72); BP (1 mmHg at 50°C).

**CHEMICAL PROPERTIES:** combustible liquid; heat contributes to instability; reacts vigorously with strong oxidizers and sulfuric acid; FP (106°C, 223°F); LFL/UFL (1.6%, not determined); AT (305°C, 581°F); HC (NA); HF (-9.7 KJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or open flame; NFPA rating Health 2, Flammability 1, Reactivity 4; reacts explosively with strong alkali, such as sodium hydroxide; incompatible with sulfuric acid, alkalies, oxidizing materials, and reducing agents; decomposition emits toxic fumes of oxides of nitrogen and carbon monoxide; use water spray, fog, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation, ingestion, or skin absorption (headache, flushed face, dizziness, dyspnea, nausea)

**HUMAN TOXICITY DATA:** material is moderately toxic to humans; between one ounce and one pint may be fatal; toxic on ingestion, inhalation, or by absorption through skin; individuals with anemia, pulmonary, or cardiovascular diseases may show more susceptibility to nitrotoluene poisoning.

**ACUTE HEALTH RISKS:** irritation of skin eyes, and respiratory system; headache; nausea; vomiting; dizziness; weakness; anoxia; cyanosis; flushing of face; difficulty breathing; muscular weakness; increased pulse rate; increased respiratory rate; irritability; tachycardia.

**CHRONIC HEALTH RISKS:** skin, eye, and respiratory irritation; destructive to tissues of mucous membranes; may possibly alter genetic material; anemia; cardiovascular disease; pulmonary disease.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2ppm (skin); OSHA PEL TWA 5 ppm (30mg/m<sup>3</sup>)(skin); NIOSH REL TWA 2 ppm (11mg/m<sup>3</sup>)(skin); IDLH 200 ppm.

**PERSONAL PROTECTION:** wear protective rubber overclothing; wear butyl rubber gloves and boots; chemical safety goggles and self-contained breathing apparatus is recommended.

**SPILL CLEAN-UP:** ventilate area of spill; shovel small quantities of solid nitrotoluene into suitable dry container; large quantities of solid may be dissolved in flammable solvent and burned in suitable combustion chamber equipped with effluent gas cleaning device; cover large quantities of liquid nitrotoluene in noncombustible material; atomize in suitable combustion chamber equipped with effluent gas cleaning device.

**DISPOSAL AND STORAGE METHODS:** absorb liquid nitrotoluene in noncombustible materials such as dry earth, sand or vermiculite and place in a sanitary landfill; atomize large amounts of liquid in a suitable combustion chamber equipped with effluent gas cleaning device; sweep solid nitrotoluene into suitable dry containers; material may be incinerated or buried in an approved chemical waste landfill; store in a cool, dry location; separate from acids, alkalis, oxidizing materials, and reducing agents..

**REGULATORY INFORMATION:** Sf1; T30-e8; T120-d10; A1; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of various synthetic dyes, toluidines, and nitrobenzoic acid; used as a chemical intermediate for dinitrotoluenes and p-nitrobenzaldehyde; used in the synthesis of explosives.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 13; 14.

### **m-NITROTOLUENE (NO<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CH<sub>3</sub>, 137.15)**

**CAS/DOT IDENTIFICATION #:** 99-08-1/UN1664

**SYNONYMS:** 3-methylnitrobenzene, m-methylnitrobenzene, mnt, 3-nitrotoluene, meta-nitrotoluene.

**PHYSICAL PROPERTIES :** yellow liquid; weak aromatic odor; solidifies in an ice and salt cooling mixture below 59°F; miscible with alcohol and ether; soluble in benzene; soluble in water at 30°C; MP (16°C, 61°F); BP (233°C, 451°F); DN (1.1630 g/cm<sup>3</sup> at 15°C); LSG (1.16); VD (4.72); VP (1 mmHg at 50.2°C).

**CHEMICAL PROPERTIES:** combustible liquid; heat contributes to instability; reacts vigorously with strong oxidizers and sulfuric acid; FP (101°C, 214°F); LFL/UFL (1.6%, not determined); AT (NA); HC (NA); HF (-31.5 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat, flame, or oxidizers; NFPA rating Health 2, Flammability 1, Reactivity 4; probably an explosive; decomposition emits toxic fumes of oxides of nitrogen and carbon monoxide; use dry chemical, carbon dioxide, or water spray for firefighting purposes..

**HEALTH SYMPTOMS:** inhalation, ingestion, or skin absorption (headache, flushed face, dizziness, dyspnea, nausea).

**HUMAN TOXICITY DATA:** material is moderately toxic to humans; between one ounce and one pint may be fatal; toxic on ingestion, inhalation, or by absorption through skin; individuals with anemia, pulmonary, or cardiovascular diseases may show more susceptibility to nitrotoluene poisoning.

**ACUTE HEALTH RISKS:** irritation of skin eyes, and respiratory system; headache; nausea; vomiting; dizziness; weakness; anoxia; cyanosis; flushing of face; difficulty breathing; muscular weakness; increased pulse rate; increased respiratory rate; irritability; tachycardia.

**CHRONIC HEALTH RISKS:** skin, eye, and respiratory irritation; destructive to tissues of mucous membranes; may possibly alter genetic material; anemia; cardiovascular disease; pulmonary disease.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2ppm (skin); OSHA PEL TWA 5 ppm (30mg/m<sup>3</sup>)(skin); NIOSH REL TWA 2 ppm (11mg/m<sup>3</sup>)(skin); IDLH 200 ppm.

**PERSONAL PROTECTION:** wear protective rubber overclothing; wear butyl rubber gloves and boots; chemical safety goggles and self-contained breathing apparatus is recommended.

**SPILL CLEAN-UP:** ventilate area of spill shovel; small quantities of solid nitrotoluene into suitable dry container; large quantities of solid may be dissolved in flammable solvent and burned in suitable combustion chamber equipped with effluent gas cleaning device; cover large quantities of liquid nitrotoluene in noncombustible material; atomize in suitable combustion chamber equipped with effluent gas cleaning device.

**DISPOSAL AND STORAGE METHODS:** absorb liquid nitrotoluene in noncombustible materials such as dry earth, sand or vermiculite and place in a sanitary landfill; atomize large amounts of liquid in a suitable combustion chamber equipped with effluent gas cleaning device; sweep solid nitrotoluene into suitable dry containers; material may be incinerated or buried in an approved chemical waste landfill; store in a cool, dry location; separate from acids, alkalies, oxidizing materials, and reducing agents..

**REGULATORY INFORMATION:** Sfl; A1; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of various synthetic dyes, toluidines, and nitrobenzoic acid; used as a chemical intermediate for dinitrotoluenes and p-nitrobenzaldehyde; used in the synthesis of explosives.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 13; 14.

**p-NITROTOLUENE (NO<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CH<sub>3</sub>, 137.15)**

CAS/DOT IDENTIFICATION #: 99-99-0/UN1664

**SYNONYMS:** 1-methyl-4-nitrobenzene, 4-methylnitrobenzene, p-methylnitrobenzene, 4-nitrotoluene, para-nitrotoluene.**PHYSICAL PROPERTIES :** yellowish crystals from alcohol; weak, aromatic odor; soluble in alcohol, benzene, ether, chloroform, acetone, carbon tetrachloride, pyrimidine, and toluene; insoluble in water; MP (54°C, 130°F); BP(238°C, 460°F); DN (1.1038 g/cm<sup>3</sup> at 75°C); SG (1.12); ST (36.83 dynes/cm at 60°C); CP (172.3 J/K-mol crystal at 25°C); HV (11.915 kcal/gmol); VD (4.72); VP (4.72); VP (0.1 mmHg at 20°C).**CHEMICAL PROPERTIES:** combustible solid; heat contributes to instability; reacts vigorously with strong oxidizers and sulfuric acid; FP (106°C, 223°F); LFL/UFL (1.6%, not determined); AT (390°C, 734°F); HC (897 kcal liquid at 20°C, 888.6 kcal solid at 20°C); HF (-48.1 kJ/mol crystal at 25°C); H<sub>f</sub> (16.8 kJ/mol at 324.7K).**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; reaction with sodium forms an ignitable product; NFPA rating Health 3, Flammability 1, Reactivity 0; reacts violently with concentrated sulfuric acid (above 160°C); forms highly explosive mixtures with tetranitromethane; may explode on standing; involved in many plant scale explosions; residue from vacuum distillation may explode spontaneously; combustion by-products include oxides of nitrogen and carbon monoxide; use dry chemical, carbon dioxide, or water spray for firefighting purposes.**HEALTH SYMPTOMS:** inhalation, ingestion, or skin absorption (headache, flushed face, dizziness, dyspnea, nausea).**HUMAN TOXICITY DATA:** material is moderately toxic to humans; between one ounce and one pint may be fatal; toxic on ingestion, inhalation, or by absorption through skin; individuals with anemia, pulmonary, or cardiovascular diseases may show more susceptibility to nitrotoluene poisoning.**ACUTE HEALTH RISKS:** irritation of skin eyes, and respiratory system; headache; nausea; vomiting; dizziness; weakness; anoxia; cyanosis; flushing of face; difficulty breathing; muscular weakness; increased pulse rate; increased respiratory rate; irritability; tachycardia.**CHRONIC HEALTH RISKS:** skin, eye, and respiratory irritation; destructive to tissues of mucous membranes; may possibly alter genetic material; anemia; cardiovascular disease; pulmonary disease.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2ppm (skin); OSHA PEL TWA 5 ppm (30mg/m<sup>3</sup>)(skin); NIOSH REL TWA 2 ppm (11mg/m<sup>3</sup>)(skin); IDLH 200 ppm.**PERSONAL PROTECTION:** wear protective rubber overclothing; wear butyl rubber gloves and boots; chemical safety goggles and self-contained breathing apparatus is recommended.**SPILL CLEAN-UP:** ventilate area of spill; shovel small quantities of solid nitrotoluene into suitable dry container; large quantities of solid may be dissolved in flammable solvent and burned in suitable combustion chamber equipped with effluent gas cleaning device; cover large quantities of liquid nitrotoluene in noncombustible material; atomize in suitable combustion chamber equipped with effluent gas cleaning device.

**DISPOSAL AND STORAGE METHODS:** absorb liquid nitrotoluene in noncombustible materials such as dry earth, sand or vermiculite and place in a sanitary landfill; atomize large amounts of liquid in a suitable combustion chamber equipped with effluent gas cleaning device; sweep solid nitrotoluene into suitable dry containers; material may be incinerated or buried in an approved chemical waste landfill; store in a cool, dry location; separate from acids, alkalies, oxidizing materials, and reducing agents.

**REGULATORY INFORMATION:** Sf1; A1; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the manufacture of various synthetic dyes, toluidines, and nitrobenzoic acid; used as a chemical intermediate for dinitrotoluenes and p-nitrobenzaldehyde; used in the synthesis of explosives.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 13; 14.

### **BENOMYL (C<sub>14</sub>H<sub>18</sub>N<sub>4</sub>O<sub>3</sub>, 290.36)**

**CAS/DOT IDENTIFICATION #:** 17804-35-2/UN2757

**SYNONYMS:** 1-(butylcarbamoyl)-2-benzimidazolecarbamic acid methyl ester, dupont 1991, fundasol, fungicide 1991, methyl-1-(butylcarbamoyl)-2-benzimidazolecarbamate.

**PHYSICAL PROPERTIES :** white, crystalline solid; faint, acrid odor; very slightly soluble in water; soluble in ethanol, heptane, chloroform, xylene, acetone, and dimethylformamide; MP (300°C, 572°F); BP (decomposes); DN (data not available); SG (data not available); VD (data not available) VP (<0.1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; dissociates in some solvents to form carben-dazim and butyl isocyanate; decomposes in aqueous solution to methyl n-(benzimidazolyl) carbamate and the ethyl analog; decomposes without melting above 300°C (572°F); decomposed by strong acids and strong alkalies; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; substance itself does not burn but may decompose upon heating; NFPA rating (not published); containers may explode when heated; non-volatile at room temperature; subject to decomposes on storage in presence of moisture; incompatible with strong acids and alkaline materials; toxic gases, such as oxides of nitrogen, may be released in a fire; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory tract); contact (skin sensitization, redness, skin rash, skin allergies); ingestion (nausea, vomiting, abdominal cramps, salivation, reproductive effects).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with large amounts of soap and water; if breathing is difficult, give oxygen; if breathing has stopped, perform artificial respiration; in case of ingestion, drink large amounts of water and induce vomiting by giving syrup of ipecac; seek medical attention.

**HUMAN TOXICITY DATA:** skin-man 0.1%; reaction: mild; cytogenetic analysis-human HeLa cell 100µmol/L; cytogenetic analysis-human liver 100µmol/L; cytogenetic analysis-human lymphocyte 10mg/L; sister chromatid exchange-human lymphocyte 250µg/L; micro-

nucleus test-human lymphocyte 10mg/L; sex chromosome loss/non-disjunction-human lymphocyte 1 mg/L; other mutation test systems-human lymphocyte 2 mg/L.

**ACUTE HEALTH RISKS:** irritation to eyes and upper respiratory tract; can cause skin irritation and rash; nausea; vomiting; abdominal; cramps; salivation; sweating; lassitude (weakness); muscular incoordination; angina pectoris; central nervous system depression; reproductive effects; cholinesterase inhibition.

**CHRONIC HEALTH RISKS:** may cause skin sensitization with irritation, redness, and cholinesterase inhibition; may cause mutations (genetic changes) in living cells; may possibly cause reproductive damage in humans; may be a teratogen in humans; damages the male reproductive system; decreases sperm count in animals; may cause a skin allergy.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.84 ppm (10mg/m<sup>3</sup>); OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL (no recommended exposure limit for benomyl); IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical-safety goggles or face shields should be worn; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing apparatus; for extra personal protection, use P3 filter respirator for toxic particles, maintain eyewash bath and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; for dry spills, use a vacuum or moisten to reduce dust dispersion, and place into dry, sealable containers; absorb liquid spills with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a chemical waste container.

**DISPOSAL AND STORAGE METHODS:** powdered material by deposited in sealed containers, and then placed in a specified landfill site; containers that are not to be reused; should be punctured and transported to a scrap metal facility for recycling, disposal or burial in secured, sanitary landfill; absorb liquid in sand or inert absorbent, and place in a designated landfill store in a cool, dry location; maintain adequate ventilation; keep dry during storage to avoid certain chemical changes affecting fungicidal effectiveness; store in tightly closed containers; should be stored separately from strong acids, strong alkalies, heat, sparks, and open flame.

**REGULATORY INFORMATION:** F2; F7; F8; R4; U waste # (U271); S1; S3; A1; CAL.

**OTHER COMMENTS:** used as a fungicide and as an ascaricide, effective against a wide range of fungi affection field crops, fruits, nuts, ornamentals and turf; used as pre- and post-harvests sprays for control of storage rots of vegetables and fruits; also used as an oxidizer in sewage treatment.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 15; 16; 18.

### **OCTANE (CH<sub>3</sub>(CH<sub>2</sub>)<sub>6</sub>CH<sub>3</sub>, 114.26)**

**CAS/DOT IDENTIFICATION #:** 111-65-9/UN1262

**SYNONYMS:** n-octane, normal octane.

**PHYSICAL PROPERTIES :** clear, colorless liquid; gasoline-like odor; miscible with benzene, petroleum ether, and gasoline; soluble in ether; slightly soluble in alcohol; practically

insoluble in water; MP (-57°C, -71°F); BP (126°C, 259°F); DN (0.7036 g/mL at 20°C); LSG (0.70); ST (21.14 mN/m at 25°C); VS (0.508 mPa-s at 25°C); CP (254.6 J/K-mol liquid at 25°C); HV (41.49 kJ/mol at 25°C); VD (3.9); VP (14 mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; heat will contribute to instability; hazardous polymerization will not occur; quickly evaporates when released to water; when released into air, degrades readily by reaction with photochemically produced hydroxyl radicals; FP (13°C, 55°F); LFL/UFL (1.0%, 6.5%); AT (220°C, 428°F); HF (-250.1 kJ/mol liquid at 25°C); H<sub>f</sub> (20.7 kJ/mol at 216.3K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; NFPA rating Health 0, Flammability 3, Reactivity 0; very dangerous fire risk and severe explosion hazard; vapor-air mixtures are explosive within flammable limits above the flash point; sensitive to static discharge; incompatible with heat, flame, and strong oxidizers; carbon monoxide and carbon dioxide may form when heated to decomposition; use dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates mucous membranes, mild narcotic effects, drowsiness, unconsciousness, death); skin/eye contact (mild irritation, redness, pain); ingestion (abdominal pain, nausea, aspiration into lungs can produce severe lung damage).

**FIRST AID:** immediately flush eyes with plenty of water; wash skin immediately with soap or mild detergent and water; provide oxygen or artificial respiration; if ingested, give large quantities of water and get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes and nose; irritation of mucous membranes; mild narcosis; abdominal pain; nausea; severe lung damage; chemical pneumonia; drowsiness; loss of consciousness; death.

**CHRONIC HEALTH RISKS:** prolonged or repeated skin contact may cause dermatitis; affects central nervous system; persons with pre-existing skin disorders or impaired pulmonary function may be more susceptible to the effects of this substance.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 300 ppm; ACGIH TLV STEL 375 ppm; OSHA PEL TWA 500ppm (2350 mg/m<sup>3</sup>); NIOSH REL TWA 75 ppm (350mg/m<sup>3</sup>); NIOSH REL CL 385 ppm (1800 mg/m<sup>3</sup>); IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, proper gloves, lab coat, apron or coveralls; use chemical safety goggles and/or full face shield where splashing is possible; use positive pressure self-contained breathing apparatus; eye wash fountains and quick-drench facilities should be provided in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; contain and reclaim liquid when possible; collect liquid in an appropriate container or absorb with an inert material (e.g., dry sand, earth, vermiculite), and place in a chemical waste container; flush remaining octane with large amounts of water, but not into spaces such as sewers because of danger of explosion; if leak or spill has not ignited, use water spray to disperse the vapor; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; handle as a hazardous waste and send to a RCRA approved incinerator or dispose of in a RCRA approved waste facility; store in a cool, dry location with adequate ventilation; outside storage is preferred; keep away from any area where the fire hazard may be acute; separate from incompatibles; storage areas should be No Smoking areas;

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containers should be bonded and grounded for transfers to avoid static sparks; use non-sparking type tools and equipment, including explosion proof ventilation.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent; useful in organic synthesis, calibrations, and azeotropic distillations; addition of tetraethyllead to isooctane has obtained octane rating as high as 115; premium leaded gasolines have a Research Octane Number (RON) of about 100, but this value drops to 85-90 for unleaded gasolines; octane rating scale ends at 125, and any higher figure is meaningless.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **OIL MIST, MINERAL (NA, varies)**

**CAS/DOT IDENTIFICATION #:** 8012-95-1/none

**SYNONYMS:** adepsine oil, alboline, crytosol, heavy liquid petrolatum, heavy mineral oil, liquid paraffin, liquid vaseline, paraffin oil, white mineral oil.

**PHYSICAL PROPERTIES :** colorless, oily liquid aerosol dispersed in air; odor like burned lubricating oil; develops not more than a faint odor of petroleum when heated; practically tasteless even when warmed; soluble in benzene, chloroform, ether, carbon disulfide, and petroleum ether; insoluble in water and alcohol; soluble in volatile oils; miscible with most fixed oils; not miscible with castor oil; free or nearly free from fluorescence; FRZP (-17.8°C, 0°F); BP (360°C, 680°F); DN (0.83-0.86 g/mL (light), 0.875-0.905 g/mL (heavy)); LSG (0.90); ST (slightly <35 dynes/cm at 25°C); KINEMATIC VS (not less than 38.1 centistokes at 37.8°C); VP (< 0.5 mmHg at 20°C).

**CHEMICAL PROPERTIES:** normally stable, even under fire exposure conditions; hazardous polymerization will not occur; does not react with water; when oxidation and peroxidation occurs in mineral oils it continues almost at a logarithmic rate; no incompatibilities and reactivities reported; FP (193°C, 380°F (open cup), 135°C, 275°F (closed cup)); LFL/UFL (unknown); AT (260-371°C, 500-700°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 0, Flammability 1, Reactivity 0; must be preheated before ignition will occur; water or foam may cause frothing if it sinks below the surface of the burning liquid and turns to steam; heating to decomposition emits irritating smoke and fumes; employees must be trained and equipped as stated in OSHA 1910.156 if they are expected to fight fires; use water to keep fire-exposed containers cool; use dry chemical, carbon dioxide, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (aspiration pneumonia, cough, breathing difficulty, irritates eyes, skin, and respiratory system); skin contact (acne-like rash, skin allergy, itching).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash skin with plenty of soap and water; if breathing is difficult, remove to fresh air immediately; other measures are unusually unnecessary.

**HUMAN TOXICITY DATA:** inhalation-man TCLO<sub>5</sub> 5mg/m<sup>3</sup>/5Y-intermittent; toxic effects: gastrointestinal tumors, carcinogenic effects, teratogenic effects, tumorigenic effects-testicular tumors.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; cough; shortness of breath; inflammation of the lungs (lipoid pneumonitis).

**CHRONIC HEALTH RISKS:** prolonged contact may cause skin irritation; can also cause an acne-like rash; may cause a skin allergy; may be carcinogenic, producing gastrointestinal tumors; adversely affects reproduction; human teratogenic effects, causing testicular tumors in the fetus; chronic diarrhea; vomiting; abdominal pain; lassitude; thirst; weakness; edema; bone pain resulting from osteomalacia; weight loss.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg/m<sup>3</sup>; ACGIH TLV STEL 10 mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; NIOSH REL STEL 10 mg/m<sup>3</sup>; IDLH 2500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; wear splash-proof chemical goggles when working with oils; enclose systems and/or provide local exhaust ventilation at the site of chemical release; use any appropriate escape-type, self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak; absorb small quantities on paper towels and evaporate in a safe place (such as a fume hood); a sufficient amount of time should be allowed so that evaporating vapors can completely clear the hood ductwork; cautiously burn paper in a suitable location away from combustible materials; collect large quantities and atomize in a suitable combustion chamber; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** contaminated mineral oil can be disposed of by controlled incineration; alternatively, absorb in sand or other inert materials, and use for landfill at sites carefully chosen to avoid any risk of the oil causing contamination of water supplies; store in a cool, dry location; maintain adequate ventilation; sources of ignition such as smoking and open flames are prohibited where Mineral Oil Mists are used, handled, or stored.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as an ingredient in various pharmaceutical preparations (processing aids, intestinal lubricants), cosmetics (cold creams hair preparations), food applications (release agents, binders, protective coatings, food packaging and processing, and chemical and plastics industry); common or main ingredient in baby oils or agents used to improve sheen of livestock hair for shows; also used in hydraulic fluid for hydrostatic machines (e.g., machine tools, presses, and construction machinery); useful as a liquid insulating material and a component of the negative plate of lead-acid batteries; mineral oil is combined with phenolphthalein in some multiple ingredients.

**KEY REFERENCES:** 4; 5; 6; 15.

### **OSMIUM TETROXIDE (OsO<sub>4</sub>, 254.20)**

**CAS/DOT IDENTIFICATION #:** 20816-12-0/UN2471

**SYNONYMS:** osmic acid, osmium (VIII) oxide, perosmic acid anhydride, perosmic oxide.

**PHYSICAL PROPERTIES :** colorless, crystalline solid or pale-yellow mass; dimorphic, having both crystalline and amorphous forms; pungent, chlorine-like odor; a liquid above 105°F (40.6°C); soluble in benzene, carbon tetrachloride, ethanol, and diethyl ether;

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also soluble in ammonium hydroxide and phosphorus oxychloride; sparingly soluble in dilute sulfuric acid and water; MP (40.6°C, 105°F); BP (130°C, 226°F at 760 mmHg); DN (4.906 g/cm<sup>3</sup> at 22°C); SG (4.90); CP (74.1 J/K-mol gas at 25°C); VD (8.8); VP (7 mmHg at 20°C); OT (0.02 mg/L in air).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; beings to sublime and distill well below the boiling point; a strong catalyst; can react with some organic compounds or reducing agents; FP (NA); LFL/UFL (NA); AT (NA); HF (-394.1 kJ/mol crystal at 25°C); H<sub>f</sub> (9.8 kJ/mol at 314K).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating Health 4, Flammability 0, Reactivity 0; not considered to be a fire hazard; not considered to be an explosion hazard; contact with oxidizable substances may cause extremely violent combustion; may react violently with some organic compounds or reducing agents; contact with hydrochloric acid causes formation of chlorine gas; explodes on contact with 1-methylimidazole; catalytic decomposition of hydrogen peroxide may cause fires and explosions; heating to decomposition emits highly toxic fumes of osmium; for extinguishing surrounding fire, use any means suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, choking, headache, dizziness, tightness in chest, bluish discoloration of skin, difficulty in breathing, kidney damage, pulmonary edema); skin contact (severe pain, ulceration, dermatitis, brownish or yellowish stains); eye contact (pain, tearing, blurred vision or halos around lights, photophobia); ingestion (severe burns of the mouth, burning sensation in the pharynx, abdominal pain, bloody diarrhea).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and give oxygen; if not breathing, give artificial respiration; in case of ingestion, drink large amounts of water and get medical attention.

**HUMAN TOXICITY DATA:** inhalation-man TCLo 133µg/m<sup>3</sup>; toxic effect: eye , pulmonary system; investigated as a mutagen, reproductive effector.

**ACUTE HEALTH RISKS:** irritation of eyes and respiratory system; coughing; choking; dyspnea; headache; dizziness; tightness in chest; pulmonary edema; cyanosis; kidney damage; severe burning pain in mouth and pharynx; abdominal pain; vomiting; diarrhea, containing dark precipitated blood; causes severe skin burns; ulceration; dermatitis; brownish or yellowish staining of skin; conjunctival edema; corneal destruction; blurred vision; lacrimation; photophobia.

**CHRONIC HEALTH RISKS:** chronic coughs; sterile lung abscess; gangrene; bronchopneumonia; structural or functional changes in trachea or bronchi.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.20 ppb; ACGIH TLV STEL 0.60 ppb; OSHA PEL TWA 0.002 mg/m<sup>3</sup>; NIOSH REL TWA 0.0002 ppm (0.002 mg/m<sup>3</sup>); NIOSH REL STEL 0.0006 ppm (0.006 mg/m<sup>3</sup>); IDLH 1 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear a full-facepiece self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; pick up and place in a suitable container for proper disposal; use a method that does not generate dust, such as wet vacuuming; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** should be handled as hazardous waste and sent to a RCRA approved waste facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; protect against physical damage; separate from incompatible substances.

**REGULATORY INFORMATION:** R4; P waste # (P087); Reportable Quantity (RQ); 1000 lbs. (454 kg); Sf1; Sf3; A1; A5; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as an oxidation catalyst in organic synthesis, particularly for converting alkenes to glycols; also catalyzes peroxide, chlorate, periodate, and other oxidation reactions; useful in microscopic staining and photography.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### **OXALIC ACID (C<sub>2</sub>H<sub>2</sub>O<sub>4</sub>, 90.04)**

**CAS/DOT IDENTIFICATION #:** 144-62-7/NA

**SYNONYMS:** ethanedioic acid, oxalic acid (aqueous), oxalic acid dihydrate.

**PHYSICAL PROPERTIES :** colorless powder or granular solid; odorless; anhydrous form is an odorless, white solid; anhydrous oxalic acid is also orthorhombic and hygroscopic; moderately soluble in ethanol; slightly soluble in diethyl ether; practically insoluble in benzene, chloroform, and petroleum ether; MP (101-102°C, 214-215.6°F dihydrate, 189.5°C, 373°F anhydrous); BP (sublimes); DN (1.90 g/mL at 17°C); SG (1.90); CP (91.0 J/K-mol crystal at 25°C); VP (<0.001 mmHg).

**CHEMICAL PROPERTIES:** combustible solid; gives off water of crystallization at 215°F and begins to sublime; anhydrous form sublimes best at 157°C (315°F); decomposes into carbon dioxide, carbon monoxide, formic acid, and water; reacts with strong alkalis, strong oxidizing materials, chlorites, and hypochlorites; forms highly insoluble calcium oxalate; FP (NA); LFL/UFL (NA); AT (NA); HF (-821.7 kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS:** not flammable; poisonous gases are produced in fire; NFPA rating Health 3, Flammability 1, Reactivity 0; reacts with some silver compounds to form explosive silver oxalate; reacts explosively with strong oxidizing materials; violent reaction with furfuryl alcohol, silver, sodium chlorate, and NaOCl; combustion may produce toxic gases, including formic acid; use water spray, dry chemical, alcohol foam, or carbon dioxide for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (severely irritates eyes and upper respiratory tract, gastrointestinal disturbances, albuminuria, gradual weight loss, increasing weakness, ulceration of the mucous membranes of the nose and throat, headache, nosebleed, nervousness); ingestion (severe gastroenteritis, vomiting, diarrhea, renal damage, corrosion of the mouth, esophagus, and stomach); contact (skin lesions, dermatitis, slow-healing ulcers, brittle and yellow nails, possible gangrene).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and mucous membranes; corrosion of the mouth, esophagus, and stomach; vomiting; burning and abdominal pain; collapse; convulsions; diarrhea; nausea; shock; severe irritation of eyes and upper respiratory tract; gastrointestinal disturbances; albuminuria; weakness; headache; nervousness; epistaxis (nosebleed); gradual weight loss; coma; death.

**CHRONIC HEALTH RISKS:** chronic cough; pain in the back; gradual emaciation; skin lesions; development of slow-healing ulcers; bluish skin; brittle and yellow nails; dermatitis; possible gangrene of the fingers; kidney disturbances; removal of calcium in the blood; obstruction of renal tubules; ulceration of the mucous membranes of the nose and throat; nervous system complaints; gastrointestinal disturbances.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg/m<sup>3</sup>; ACGIH TLV STEL 2 mg/m<sup>3</sup>; OSHA PEL TWA 1 mg/m<sup>3</sup>; OSHA PEL STEL 2mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; NIOSH REL STEL 2mg/m<sup>3</sup>; IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective rubber overclothing, including gloves; wear chemical safety goggles and self-contained breathing apparatus..

**SPILL CLEAN-UP:** shovel into suitable dry container; clean up and remove any spilled solid.

**DISPOSAL AND STORAGE METHODS:** solid acid may be packaged and burned in incinerator; dissolve in flammable solvent and burn in incinerator equipped with effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from strong oxidizers, strong alkalis, silver compounds and chlorites..

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used in purifying methanol, for decolorizing crude glycerol and for stabilizing hydrocyanic acid; used in removing paint or varnish, rust or ink stains, and in cleaning wood; used in metallurgy as a cleanser, in the paper industry, in photograph, in process engraving, and in the rubber manufacturing industry; useful as an analytical reagent and as a condensing agent in organic chemistry; also used in making glucose from starch.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 10; 14.

## **OXYGEN DIFLUORIDE (OF<sub>2</sub>, 54.0)**

**CAS/DOT IDENTIFICATION #:** 7783-41-7/UN2190

**SYNONYMS:** difluoride monoxide, fluorine monoxide, fluorine oxide, oxygen fluoride.

**PHYSICAL PROPERTIES:** colorless, compressed gas; yellowish-brown when liquid; peculiar, foul odor; slightly soluble in water and alcohol; gas is heavier than air; MP (-224°C, -371°F); BP (-145°C, -229°F); DN (1.90 g/mL liquid at -224°C); CP (43.3 J/K-mol gas at 25°C); HV (11.09 kJ/mol at 128.40K); VD (1.88); VP (> 1 atm at 20°C).

**CHEMICAL PROPERTIES:** generally, an unstable gas; stable in dry glass vessels; remains stable to 2°C (35.6°F); will not attack glass in the cold; gas will remain unchanged for a month when kept over water; corrosive to mercury; reacts very slowly with water, forming

hydrofluoric acid; less reactive than chlorine oxide ( $\text{Cl}_2\text{O}$ ), but reacts with mercury (Hg); FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (24.7 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; not combustible, but enhances combustion of other substances; gaseous mixtures with hydrocarbons may cause fire and explosion; NFPA rating (NA); mixture with water or water vapor explodes violently on spark ignition; substance is a powerful oxidizer and reacts vigorously with combustible and reducing materials; explosive reaction with hydrogen sulfide at ambient temperatures; reacts explosively with chlorine, bromine or iodine on warming; explodes on contact with steam; undergoes an explosive and exothermic reaction with non-metals such as red phosphorus, boron powder, and silicon; reaction with alumina, silica gel or similar surface-active solids may also be explosive; incandescent reaction with aluminum, magnesium, barium, cadmium, zinc, zirconium, strontium, sodium, lithium (above 400°C) and potassium (above 400°C); incompatible with ammonia, ozone, iridium, palladium, platinum, rhodium, ruthenium, silicon dioxide, arsenic trioxide, and chromium trioxide; decomposes on heating above 250°C (482°F), producing toxic fumes of fluorine; in case of fire in the surroundings, all extinguishing agents may be used for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, lung edema, irritates eyes, skin and respiratory system); contact (severe, deep burns of eyes and skin, liquid may cause frostbite).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; flush affected areas of skin with large amounts of water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** inhalation-human T<sub>CLo</sub> 500 ppb; toxic effect: pulmonary system.

**ACUTE HEALTH RISKS:** severe irritation of eyes, skin, and respiratory tract; corrosive to tissues of mucous membranes; may cause pulmonary edema; exposure at low levels may result in severe headache; severe eye and skin burns from contact with gas under pressure; contact with liquid may cause frostbite.

**CHRONIC HEALTH RISKS:** chronic pulmonary edema or congestion; may impair lungs with delayed symptoms.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 0.05 ppm (0.11 mg/m<sup>3</sup>); OSHA PEL TWA 0.05 ppm (0.1 mg/m<sup>3</sup>); NIOSH REL CL 0.05 ppm (0.1 mg/m<sup>3</sup>); IDLH 0.5 ppm.

**PERSONAL PROTECTION:** wear complete protective clothing, including cold-insulating gloves; wear chemical safety goggles or face shield; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of spill or leak; if possible, stop gas leak without risk; absorb liquid spills with inert materials (e.g., dry earth, sand or vermiculite), and place in chemical waste container; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** use fine spray of water to cool and reduce vapors; absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry location; use only with adequate ventilation; fireproof if in building; separate from combustible and reducing substances.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (2.3); label (poison gas, oxidizer, corrosive).

**OTHER COMMENTS:** the occupational exposure limit value should not be exceeded during any part of the working exposure; the symptoms of pulmonary edema do not become manifest until a few hours have passed; suggested use as an oxidizer for rocket propellants.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### OZONE (O<sub>3</sub>, 48.0)

**CAS/DOT IDENTIFICATION #:** 10028-15-6/none

**SYNONYMS:** triatomic oxygen.

**PHYSICAL PROPERTIES :** colorless or bluish gas or dark-blue liquid; pleasant, characteristic odor in concentrations of less than 2 ppm; very pungent and injurious odor in higher concentration; slightly soluble in water, but more soluble in water than oxygen; liquefiable at -12°C (10.4°F); MP (-193°C, -315°F); BP (-112°C, -169.6°F); DN (1.614 g/mL liquid at -195.4°C, 2.144 g/L gas at 0°C or 1.71 g/L gas at -183°C); LSG (1.61); CP (39.2 J/K-mol gas at 25°C); VD (1.66); VP (> 1 atm at 20°C); OT (1 ppm).

**CHEMICAL PROPERTIES:** unstable gas; powerful oxidizing agent; more active oxidizing agent than oxygen; reacts with combustible and reducing materials; reacts with alkenes, aromatics (such as aniline and ethers), bromine, nitrogen compounds and rubber; attacks metals except gold and platinum; FP (NA); LFL/UFL (NA); AT (NA); HF (142.7 kJ/mol gas at 25°C); T<sub>c</sub> (-12.1°C, 10.2°F); P<sub>c</sub> (53.8 atm, 40,888 mmHg).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; not combustible, but enhances combustion of other substances; NFPA rating (NA); dangerous fire and explosion risk in contact with organic metals; solutions containing ozone explode on warming; powerful oxidizing agent; unstable; stability of ozone in aqueous solutions decreases as alkalinity rises; severe explosion hazard in liquid form when shocked or exposed to heat and flame; concentrated liquid form will cause a dangerous chemical reaction with powerful reducing agents; dangerous chemical reaction with acetylene, alkenes, alkylmetals, antimony, and aromatic compounds (such as benzene and aniline); risk of fire and explosion on contact with combustible gases (e.g., carbon monoxide, ethylene, nitrogen oxide, ammonia, and phosphine), diethyl ether, 1,1-difluoroethylene, liquid hydrogen, hydrogen bromide, hydrogen iodide, nitrogen, nitrogen trichloride, nitroglycerin, and many other combustible substances; incompatible with rubber and dinitrogen tetroxide; use water spray, dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (asthmatic reactions, cough, headache, dyspnea, sore throat, impaired vigilance, and exposure, lacrimation, decreased blood pressure); contact (redness, pain, loss of vision, frostbite).

**FIRST AID:** immediately flush eyes with plenty of water; in case of frostbite, rinse skin with plenty of water and get immediate medical attention; provide 100% oxygen and artificial respiration, if indicated.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 50 ppm/30M; inhalation-human TCLo 100ppm/1M; toxic effect: skin, pulmonary system; inhalation-human TCLo 1 ppm; toxic effect: pulmonary system; inhalation-human TCLo 600ppb/2H; toxic effect: pulmonary system; inhalation-man TCLo 1860ppb/75M; toxic effect: eye, cardiovascular system, pulmonary sys-

tem; sister chromatid exchange-human lung 250ppb/1H; cytogenetic analysis-human leukocyte 7230ppb/36H.

**ACUTE HEALTH RISKS:** irritation of eyes and mucous membranes; headache; shortness of breath; sore throat; lacrimation; visual field changes; pulmonary edema; cough; respiratory stimulation; pulmonary changes; decreased pulse rate; blood pressure decrease; liquid may cause frostbite.

**CHRONIC HEALTH RISKS:** chronic respiratory disease; may alter genetic material; experimental reproductive effects; dermatitis; target eyes and respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05ppm; ACGIH TLV STEL 0.2ppm; ACGIH TLV CL 0.1 ppm (0.20 mg/m<sup>3</sup>); OSHA PEL TWA 0.1ppm (0.2 mg/m<sup>3</sup>); NIOSH REL CL 0.1 ppm (0.2mg/m<sup>3</sup>); IDLH 5ppm.

**PERSONAL PROTECTION:** wear special protective clothing, including cold-insulating gloves; face shield or eye protection is recommended; use self-contained breathing apparatus; a closed system, ventilation, and explosion-proof electrical equipment and lighting is required.

**SPILL CLEAN-UP:** evacuate danger area and consult an expert; ventilate area of spill or leak; if in liquid state, never direct water jet on liquid.

**DISPOSAL AND STORAGE METHODS:** fireproof if in building; store in a cool, dry location with adequate ventilation; frequently stored refrigerated in halons; keep away from open flames, sparks, and combustible substances.

**REGULATORY INFORMATION:** CA1; Sf2; Sf3; A1; A5; CAL.

**OTHER COMMENTS:** used in the purification of drinking water and in industrial waste treatment; used in the deodorization of air and sewage gases, by virtue of its oxidizing power; useful for bleaching waxes, oils, textiles, and wet paper; useful oxidizing agent in several organic synthesis (e.g., acids, aldehydes, and ketones from unsaturated fatty acids), steroid hormones, removal of chlorine from nitric acid, and the oxidation of phenols and cyanides; forms ozonides which are sometimes useful oxidizing compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **PARAQUAT (CH<sub>3</sub>(C<sub>5</sub>H<sub>4</sub>N)<sub>2</sub>CH<sub>3</sub>Cl<sub>2</sub>, 257.18)**

**CAS/DOT IDENTIFICATION #:** 1910-42-5/UN2781

**SYNONYMS:** 1,1'-dimethyl-4,4'-bipyridinium dichloride, n,n'-dimethyl-4,4'-bipyridinium dichloride, methyl viologen dichloride, paraquat chloride, paraquat dichloride.

**PHYSICAL PROPERTIES:** colorless, hygroscopic crystals; water solution is dark red; faint, ammonia-like odor; very soluble in water; slightly soluble in lower alcohols, including methanol and ethanol; insoluble in non-polar solvents; MP (300°C, 572°F (decomposes)); BP (decomposes); DN (1.25 g/cm<sup>3</sup>); SG (1.25); VD (6.4-8.9); VP (<1 x 10<sup>-7</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; non-volatile; hydrolyzed by bases; reacts with strong oxidizers; inactivated by inert clays and by anionic surfactants; unformulated products are corrosive to common metals; decomposes under influence of ultraviolet light; FP (NA); LFL/UFL (NA); AT (NA); HC (NA)

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**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); not considered to be a fire hazard; not considered to be an explosion hazard; contact with strong oxidizers may cause fires and explosions; decomposes on heating above 300°C (572°F) and in presence of ultraviolet light, producing toxic and corrosive fumes of hydrogen chloride, carbon monoxide, and oxides of nitrogen; in case of fire in the surroundings, use water spray, powder, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, sore throat, labored breathing, lung damage, reduces capacity of lung to absorb oxygen, edema, anoxia); skin absorption (nose-bleeding, redness, skin burning, loss of fingernails); ingestion (burning in the mouth and throat, nausea, vomiting, abdominal pain, diarrhea, ulceration of digestive tract, renal damage, hemorrhage and fibrosis of lung, liver damage with yellow jaundice, heart damage).

**FIRST AID:** wash eyes immediately with plenty of water for several minutes; wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, rinse mouth; give plenty of water or bentonite clay in water, or give a slurry of activated charcoal in water to drink; induce vomiting, then seek medical attention.

**HUMAN TOXICITY DATA:** oral-human LDLo 214 mg/kg; oral-man TDLo 32 mg/kg; toxic effect: pulmonary effects, gastrointestinal tract; oral-man LDLo 43 mg/kg; oral-woman LDLo 111 mg/kg; toxic effect: pulmonary effects, gastrointestinal tract, kidney; oral-woman LDLo 3000 mg/kg; toxic effect: central nervous system, pulmonary effects, gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory tract; cough; dyspnea; headache; acute renal failure; acute tubular necrosis; pulmonary edema; epistaxis (nosebleed); hypermotility; nausea; vomiting; diarrhea; ulceration or bleeding from stomach; lung hemorrhage and fibrosis; may impair lungs, kidneys, liver, cardiovascular system and gastrointestinal tract; may cause tissue lesions; may cause death in high concentrations.

**CHRONIC HEALTH RISKS:** prolonged contact with skin may cause dermatitis, loss of fingernails, and other abnormalities; may cause permanent lung damage; implications in aplastic anemia; experimental reproductive effects have been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1mg(respirable fraction)/m<sup>3</sup>; OSHA PEL TWA 0.5mg(respirable fraction)/m<sup>3</sup>(skin), NIOSH REL TWA 0.1mg(respirable fraction)/m<sup>3</sup>(skin); IDLH 1 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles or face shield in combination with breathing protection if powder; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use positive pressure self-contained breathing apparatus in unknown concentrations; for extra personal protection, wear P3 filter respirator for toxic particles; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; collect spilled liquid in sealable containers or absorb in noncombustible materials (e.g., dry earth, sand, vermiculite); sweep solid substance into dry, sealable containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** solid may be disposed of in sealed containers in a designated landfill; absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry location; keep in the dark; maintain adequate ventilation; keep locked up; separate from strong oxidants, strong bases, food and feedstuffs.

**REGULATORY INFORMATION:** F1; F2; F7; F8; Sf2; Sf3; A1; CAL; DOT hazard class/division (6.1).

**OTHER COMMENTS:** Paraquat is a cation (1,1-dimethyl-4,4'-bipyridinium), CAS No. 4685-14-7; commercial product is the dichloride salt of paraquat, CAS No. 1910-42-5; a dimethyl sulfate salt, a yellow solid, CAS No. 2074-50-2, has also been commercialized; has been used as an agricultural herbicide, desiccant, and defoliation agent during pre-harvest; used to control aquatic weeds; dichloride has been utilized as a biological oxidation-reduction indicator; use has been restricted.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 16.

### **PARATHION (C<sub>10</sub>H<sub>14</sub>NO<sub>5</sub>PS, 291.28)**

**CAS/DOT IDENTIFICATION #:** 56-38-2/NA2783

**SYNONYMS:** o,o-diethyl-o-(p-nitrophenyl)phosphorothioate, diethyl-4-nitrophenyl phosphorothionate, diethylparathion, ethyl parathion, parathion-ethyl.

**PHYSICAL PROPERTIES :** pale-yellow to dark-brown liquid; solid below 43°F; may be absorbed on a dry carrier; freely soluble in alcohols, esters, ether, ketones, and aromatic hydrocarbons; insoluble in water, petroleum ether, kerosene, and usual spray oils; MP (6°C, 42.8°F); BP (375°C, 707°F); DN (1.26 g/mL at 25°C); LSG (1.27); ST (39.2 dynes/cm at 25°C); VS (15.30 cP at 25°C); VP (3.78 x 10<sup>-5</sup> mmHg at 20°C); OT (0.47 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** combustible liquid; reacts vigorously with strong oxidizers and alkaline materials; incompatible with substances having a pH higher than 7.5; FP (200°C, 392°F open cup).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating (NA); reacts violently with endrin; highly dangerous; shock can shatter the container, releasing the contents; decompositions emits highly toxic fumes of oxides of nitrogen, oxides of sulfur, and oxides of phosphorus; use dry chemical, water spray, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (vomiting, abdominal cramps, diarrhea, weakness, headache, dizziness, labored breath); contact (prickling of skin, severe eye irritation, impaired sight, narrowing of pupils); ingestion (general anesthetic, pulmonary effects, kidney and bladder effects, changes in level of cholinesterase).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** oral-human LD<sub>50</sub> 3mg/kg; oral-human LDLo 171µg/kg; skin-human LDLo 7143µg/kg; intratracheal-human LDLo 714µg/kg; oral-man TDLo 429µg/kg/4D; toxic effect: systemic effects; oral-woman TDLo 2mL/kg; oral-woman TDLo 5670µg/kg; toxic effect: central nervous system, pulmonary system, kidney; dns-human fibroblast 10µmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; miosis; rhinorrhea; tightness of chest; wheezing; laryngeal spasm; salivation; cyanosis; headache; nausea; vomiting; abdominal cramps; diarrhea; sweating; muscle twitching; weakness; giddiness; confusion; ataxia; convulsions; paralysis; low blood pressure; cardiac irregularities; anorexia; blurring

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and dimness of vision; pupillary constriction; bronchoconstriction; central nervous system depression; respiratory failure; coma; death.

**CHRONIC HEALTH RISKS:** cholinesterase inhibitor resulting in depressed red blood cell activity; depressed plasma; degenerative changes in the liver; pulmonary effects; kidney, ureter and bladder effects; nausea; headaches; methyl parathion is linked with human birth defects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.05 mg/m<sup>3</sup>(skin); IDLH 10mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing; wear rubber boots and chemical resistant gloves; wear splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb small spills using sand, clay or other inert absorbent material; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite and dispose of in sealed containers in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; storage should be in tightly sealed containers; should be kept well separated from oxidizing agents and alkaline materials.

**REGULATORY INFORMATION:** CA2; F5; R3; R4; R5; P waste # (P089); Reportable Quantity (RQ): 10 lbs. (4.54 kg); Sf1; Sf2; Sf3; CW1; CW2; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as an insecticide for fruit, cotton, wheat vegetable, and nut crops; used as an acaricide.

**KEY REFERENCES:** 3; 4; 5; 6; 12; 13; 14; 19.

**PARTICULATES** not otherwise regulated (Particulates have variable molecular formulas and variable formula weights.)

**CAS/DOT IDENTIFICATION #:** none/none

**SYNONYMS:** inert dusts, nuisance dusts, PNOR. (note: includes all inert or nuisance dusts, including mineral, organic, or inorganic, not specifically listed in 1910.1000).

**PHYSICAL PROPERTIES :** dusts from solid substances without standards relating to specific occupational exposure; contains no asbestos and less than 1% quartz; other properties vary depending upon the specific solid.

**CHEMICAL PROPERTIES:** properties vary depending upon the specific solid.

**EXPLOSION and FIRE CONCERNS:** flammability, instability and reactivity hazards vary depending upon the specific solid.

**HEALTH SYMPTOMS:** inhalation (inflammation and swelling at mucous membranes, headache, nasal dryness and hemorrhage, esophageal or pulmonary edema, coughing, wheezing, irritates eyes, skin and throat); skin contact (redness, pain, swelling, allergic dermatitis); ingestion (nausea, vomiting, diarrhea).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; after breathing large amounts of this chemical, move to fresh air immediately; other measures are usually not necessary.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found relating to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes, skin, throat, and upper respiratory system; inert materials such as wood dust and polypropylene fibers may create mild irritant effects or act in combination with other irritants to enhance adverse clinical effects in humans and animals; may cause swelling, redness and pain at site of mucous membranes; tachypnea; wheezing, and coughing occurs in 25% of inhalation irritant exposures; inhalation exposure may result in pulmonary edema; nausea; vomiting and diarrhea are possible; skin redness, swelling and pain may occur, but there should be no dermal erosions.

**CHRONIC HEALTH RISKS:** reactive airways dysfunction syndrome (RADS), referring to asthma persisting after exposure to irritants; persistence of respiratory symptoms and airway hyper-reactivity for at least 3 months; symptoms simulating asthma, with cough, wheezing, and dyspnea; prolonged exposure has been associated with allergic contact dermatitis; repeated exposure to wood dust and other irritants has contributed to risk of sinonasal neoplasms (nasal cancer).

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup> (total dust less than 1% quartz), 3 mg/m<sup>3</sup> respirable fraction; OSHA PEL TWA 15 mg/m<sup>3</sup> (total dust), 5 mg/m<sup>3</sup> (respirable fraction); NIOSH REL (not determined); IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including chemical-resistant gloves, apron or disposable coveralls; wear dust-proof safety goggles; a closed system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use positive pressure self-contained breathing apparatus in unknown concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** sweep up and containerize spill for reclamation or disposal; vacuuming or wet sweeping may be used to avoid dust dispersal.

**DISPOSAL AND STORAGE METHODS:** containerize spill for deposit in a designated landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry, well-ventilated area; keep in a tightly closed container.

**REGULATORY INFORMATION:** not regulated.

**OTHER COMMENTS:** The final recommendations of the US Consumer Safety Committee concerning irritants were issued on September 13, 1982. They listed products in 3 categories: 1. Weak irritants=**caution**=irritating to eyes, nose, throat, and mouth. 2. Strong irritants=**warning**=irritants to eyes, nose, throat, and mouth; may also irritate the skin. 3. Corrosive=**danger**=may cause permanent damage and severe burns; vapor may be harmful, or possibly fatal.

**KEY REFERENCES:** 4; 15; (note: information concerning exposure guidelines for particulates not otherwise classified was obtained from the NIOSH Manual of Analytical Methods (NMAM), Fourth Edition).

**PENTABORANE (B<sub>4</sub>H<sub>9</sub>, 63.14)**

CAS/DOT IDENTIFICATION #: 19624-22-7/UN1380

**SYNONYMS:** dihydropentaborane, pentaborane(9), pentaboron nonahydride, pentaboron undecahydride.

**PHYSICAL PROPERTIES :** colorless liquid; strong, pungent odor of sour milk; soluble in tetrahydrofuran (THF), diglyme, diethyl ether, and hexane; insoluble in water; MP (-123 to -47°C, -189 to -53°F); BP (60-63°C, 140-145°F); DN (0.61 g/mL at 0°C); LSG (0.61-0.66); CP (151.1 J/K-mol liquid at 25°C); VD (2.2); VP (66 mmHg at 0°C, 171 mmHg at 20°C); OT (2.5 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** flammable liquid; thermally unstable; corrosive to natural rubber; hydrolyzes slowly with heat in water to form boric acid; reacts with ammonia to form a diammoniate; reacts vigorously with strong oxidizers; decomposes very slowly at 150°C (302°F); FP (30°C, 86°F); LFL/UFL (0.42%, 98%); AT (35°C, 95°F); HF (42.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 4, Flammability 4, Reactivity 2; pyrophoric; dangerous fire hazard by chemical reaction; may ignite spontaneously in moist air; dangerous explosion hazard; low ignition energy; vapors may accumulate in air and explode without an ignition source; explosive decomposition may occur under fire conditions; decomposes above 300°F (149°C) if not already ignited; fires may reignite; closed containers may rupture violently when heated; reacts explosively with oxygen; violent reaction with halogenated extinguishing agents; forms shock-sensitive solutions in solvents containing carbonyl, halogens, and ether or ester functions; incompatible with dimethyl sulfoxide; combustion by-products include boron fumes and other toxic gases; use water spray, foam, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (headache, lightheadedness, drowsiness, tremors, incoherence).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water; induce vomiting if conscious.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; dizziness; headache; drowsiness; lightheadedness; incoherence; incoordination; tremors; tonic spasm of face, neck, abdomen and limbs; convulsive seizures; behavioral changes.

**CHRONIC HEALTH RISKS:** headache; fatigue; drowsiness; lack of coordination; inability to concentrate; liver and kidney damage; central nervous system effects; chronic disorders of the skin and eyes.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.005 ppm; ACGIH TLV STEL 0.013 ppm; OSHA PEL TWA 0.005 ppm (0.01mg/m<sup>3</sup>); NIOSH REL TWA 0.005 ppm (0.01 mg/m<sup>3</sup>); NIOSH REL STEL 0.015 ppm (0.03 mg/m<sup>3</sup>); IDLH 1 ppm.

**PERSONAL PROTECTION:** use impervious clothing (boots, gloves, aprons, etc.); use splash-proof safety goggles where there is any possibility of liquid pentaborane contacting the eyes; wear self-contained breathing apparatus; eye-wash fountains and showers should be provided in the immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb small quantities on paper towels and evaporate in a fume hood; absorb as much as possible with noncombustible materials such as dry earth or sand; flush remaining pentaborane with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** dispose of by atomizing in a suitable combustion chamber equipped with effluent gas cleaning device; store in a cool, dry location with adequate ventilation; store away from oxidizing agents, heat and sunlight; separate from rubber, grease, oils, halogens and oxidizing materials.

**REGULATORY INFORMATION:** Sf2; A1; A5; CAL; DOT hazard class/division (4.2); labels (spontaneously combustible, poison).

**OTHER COMMENTS:** used as a chemical intermediate in the preparation of higher boranes, alkyl boranes, ethyl pentaborane, and various hydrides; useful as jet and rocket fuels, catalysts, corrosion inhibitor fluxing agents, and oxygen scavengers.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 14; 16.

### **PETNACHLORONAPHTHALENE (C<sub>10</sub>H<sub>5</sub>Cl<sub>5</sub>, 300.38)**

**CAS/DOT IDENTIFICATION #:** 1321-64-8/ none

**SYNONYMS:** halowax<sup>®</sup> 1013, 1,2,3,4,5-pentachloronaphthalene

**PHYSICAL PROPERTIES :** pale-yellow or white solid; aromatic odor; insoluble in water; MP (120°C, 248°F); BP (327-371°C, 620-700°F at 760 mmHg); SG (1.67); VD (10.4); VP (<1 mmHg at 20°C); OT (no quantitative information is available).

**CHEMICAL PROPERTIES:** noncombustible solid; action similar to that of chlorinated naphthalenes and chlorinated diphenyls; heat may contribute to instability; can react vigorously with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (NA)

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating (NA); contact with strong oxidizing agents may cause fires and explosions; toxic gases and vapors, such as carbon monoxide and toxic chloride fumes, may be released in a fire; use dry chemical, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, vertigo, fatigue); contact (acne-form skin eruptions, pruritus, skin lesions); ingestion ( jaundice, liver necrosis, dark urine).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; promptly flush areas of skin contaminated with molten pentachloronaphthalene with large amounts of water to remove heat; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** headache; dizziness; eye and skin irritant.

**CHRONIC HEALTH RISKS:** acne-like skin rash; papules, large comedones and pustules, affecting the face, neck, arms, and legs; skin lesions; headache; vertigo; anorexia; liver damage; fatigue; dark urine; yellow jaundice; death.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>; OSHA PEL TWA 0.5 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup>(skin); IDLH (unknown).

**PERSONAL PROTECTION:** use impervious clothing, gloves, and face shields; use splash-proof safety goggles where solid pentachloronaphthalene or liquid containing pentachloronaphthalene may contact the eyes; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb liquids containing pentachloronaphthalene in noncombustible materials such as dry earth, sand, or vermiculite.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand, and dispose of in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used during the manufacture of electric equipment as an insulating material ;used as an inert compound of resins or polymers for coating or impregnating textiles, wood and paper to impart flame resistance and water proofness; useful as an additive to special lubricants in crankcase oil, lubricants for farm machinery, and extreme-pressure lubricants; an additive for cutting oil in various operations performed on metals.

**KEY REFERENCES:** 4; 5; 6; 7; 16.

### **PENTACHLOROPHENOL (C<sub>6</sub>HCl<sub>5</sub>O, 266.32)**

**CAS/DOT IDENTIFICATION #:** 87-86-5/UN3155

**SYNONYMS:** PCP, penchlorol, penta, 2,3,4,5,6-pentachlorophenol, pentacon, permatox penta, santophen.

**PHYSICAL PROPERTIES :** colorless to white, crystalline solid (pure); dark grayish powder or flakes (crude product); phenolic odor; very pungent odor only when hot; very soluble in ethanol and ethyl ether; soluble in benzene, dilute alkali, carbitol, cellosolve, and most organic solvents; slightly soluble in cold petroleum ether and paraffins; almost insoluble in water; MP (190-191°C, 374-376°F); BP (310°C, 590°F decomposes); DN (1.978 g/mL at 22°C); SG (1.98); HV (70.05 kJ/mole at 25°C); VP (0.00001 mmHg at 25°C, 40mmHg at 211.2°C); OT (857µg/L at 30°C, 12,000 µg/l at 60°C).

**CHEMICAL PROPERTIES:** stable; heating above 200°C produces traces of octachlorodibenzo-para-dioxin; corrosive in presence of moisture; reacts with acid chlorides, acid anhydrides, strong oxidizers, and strong bases; FP (none); LFL/UFL (none); AT(none); HC (not available).

**EXPLOSION and FIRE CONCERNS:** not flammable; non-combustible solid; NFPA rating Health 3; Flammability 0; Reactivity 0; incompatible with acids, alkalies, oxidizing materials, and other organic materials; hazardous decomposition products include hydrogen chloride, chlorinated phenols, and carbon monoxide; use water spray, carbon dioxide, dry chemical powder, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates skin and mucous membranes, coughing, sneezing); ingestion (loss of appetite, respiratory difficulties, anesthesia, sweating, coma); contact (dermatitis, chemical skin burns, slight eye damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-man LDLo 401mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; sneezing; coughing; motor weakness; decrease in respiration; low blood pressure; decrease in urinary output; fever; increase in bowel action; collapse; convulsions; dermatitis; headache; dizziness; nausea; vomiting; chest pain; difficult breathing; low-weight; death.

**CHRONIC HEALTH RISKS:** liver and kidney injury; may cause congenital malformation in the fetus; may alter genetic material; carcinogen; anorexia; target organs: liver and kidney.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.5mg/m<sup>3</sup>(skin); NIOSH REL TWA0.5mg/m<sup>3</sup>(skin); IDLH 2.5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear chemical protective clothing and chemical-resistant rubber gloves; wear chemical safety goggles and self-contained breathing apparatus; use only in a chemical fume hood.

**SPILL CLEAN-UP:** ventilate area of spill; shovel spilled material into suitable dry container; absorb liquid containing pentachlorophenol in noncombustible materials such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible with materials such as dry earth, sand, vermiculite, or a sand-soda ash mixture; place in a sanitary landfill or dump in closed incinerator with afterburner; dissolve in flammable solvent and spray in incinerator equipped with afterburner and alkali scrubber; store in a cool, dry location; separate from acids, alkalies, strong oxidizers, and other organic materials.

**REGULATORY INFORMATION:** CA2; S1; S24; S32-46; S50-a15; S61-C16; S62'-34; R3; R4; R5; R6; R8; R9; D waste # (D037); F waste # (F027); Reportable Quantity (RQ): 10lbs (4.54 kg); Sf1; Sf3; CW1; CW2; CW3; CW4; CW5; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** recommended for use in the preservation of starches, dextrans, and glues; used as a wood preservative; used in pressure treatment of lumber; incorporated in paints, pulp stock, in pulp, paper, and hardboard; used as a chemical intermediate for sodium pentachlorophenate; used as a soil fumigant for termites, a preharvest defoliant on selected crops, and antibacterial agent in disinfectants and cleanser, an herbicide, algacide, germicide, and fungicide; no longer available for over-the-counter sale in the United States.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

## **PENTAERYTHRITOL (C<sub>5</sub>H<sub>12</sub>O<sub>4</sub>, 136.17)**

**CAS/DOT IDENTIFICATION #:** 115-77-5/none

**SYNONYMS:** 2,2-bis(hydroxymethyl)-1,3-propanediol, methane tetramethylol, mono-pentaerythritol, pe, tetrahydroxymethylmethane, tetramethylolmethane.

**PHYSICAL PROPERTIES:** colorless to white, crystalline powder; crystals are ditetragonal; soluble in water; soluble in ethanol, ethylene glycol, glycerol, and formamide; insoluble in benzene, acetone, carbon tetrachloride, paraffins, ether and petroleum ether; MP

(260°C, 500°F)(sublimes); BP (276°C, 529°F)(sublimes); DN (1.399 g/cm<sup>3</sup> at 25°C); SG (1.38 at 20°C); VD (NA); VP (< 1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; not affected when boiled with dilute caustic alkali; readily undergoes esterification by common organic acids; can react vigorously with strong oxidizing agents; FP (unknown); LFL/UFL (unknown); AT (unknown); HC (data not available in the literature).

**EXPLOSION and FIRE CONCERNS:** combustible solid; capable of creating a dust explosion; NFPA rating (not rated); heated mixtures with thiophosphoryl chloride form a product that ignites and then explodes on contact with air; contact with strong oxidizers may cause fire and explosion; incompatible with strong acids, acid chlorides, and acid anhydrides; hazardous decomposition products include carbon monoxide and carbon dioxide; use water spray, carbon dioxide, appropriate foam, or dry chemical powder for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and respiratory system); contact (may cause skin irritation). (Note: It has been reported that the physical and toxicological properties of this chemical have not been reported).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, wash out mouth with water provided person is conscious.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system. (Note: it has been reported that the physical and toxicological properties of this chemical have not been thoroughly investigated).

**CHRONIC HEALTH RISKS:** no information found. (Note: It has been reported that the physical and toxicological properties of this chemical have not been thoroughly investigated).

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg (total dust)/m<sup>3</sup>; OSHA PEL TWA 15 mg (total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including rubber boots, gloves, lab coat, apron or coveralls; use chemical safety goggles; enclose operations and/or provide local exhaust ventilation at the site of chemical release; appropriate respirators are needed in areas where exposures are above the permissible exposure level; in unknown concentrations wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** sweep up, place in a bag, and hold for proper disposal; if appropriate, moisten first to avoid raising dust; ventilate area and wash spill site after material pick-up is complete; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber; dispose of in accordance with federal, state and local environmental regulations; store in a cool, dry location; use only with adequate ventilation; keep container tightly closed; separate from strong oxidizing agents, strong acids, acid chlorides, and acid anhydrides.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none); label (none).

**OTHER COMMENTS:** used in coatings, stabilizers, explosive, insecticides, synthetic lubricants, and pentaerythritol tetranitrate (PETN) resins; applications in paint and varnish industries.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### **PENTANE (C<sub>5</sub>H<sub>12</sub>, 72.17)**

**CAS/DOT IDENTIFICATION #:** 109-66-0/UN1265

**SYNONYMS:** amyl hydride, n-pentane, normal pentane.

**PHYSICAL PROPERTIES :** colorless liquid; gas above 97°F; gasoline-like odor; miscible in alcohol, ether, and many organic solvents; very slightly soluble in water; MP (-129.8°C, -201.6°F); BP (36°C, 97°F); DN (0.626 g/mL at 20°C); LSG (0.63); ST (15.49 mN/m at 25°C); VS (0.224 mPa-s at 25°C); CP (167.2 J/K-mol liquid at 25°C); HV (26.43 kJ/mol at 298.15K); VD (2.48); VP (426 mmHg at 20°C); OT (2.2 ppm).

**CHEMICAL PROPERTIES:** flammable liquid; heat contributes to instability; will attack some forms of plastics, rubber, and coatings; can react vigorously with strong oxidizers; FP (<-40°C, <-40°F); LFL/UFL (1.5%, 7.8%); AT (309°C, 588°F); HF (-173.5 kJ/mol liquid at 25°C); H<sub>f</sub> (8.42 kJ/mol at 143.4K).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 4, Reactivity 0; very dangerous fire hazard when exposed to heat, flame or oxidizers; severe explosion hazard; contact with strong oxidizing agents may cause fires and explosions; shock can shatter metal containers and release contents; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use foam, carbon dioxide, and dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and nose, drowsiness, loss of consciousness, death); contact (defatting of skin, blistering).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, get immediate medical attention; do not induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and nose; chemical pneumonia; drowsiness; narcotic effects; drying and cracking of skin due to defatting action; liquid can cause blisters.

**CHRONIC HEALTH RISKS:** no chronic systemic effects have been reported in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 600 ppm; ACGIH TLV STEL 750 ppm; OSHA PEL TWA 1000 ppm (2950 mg/m<sup>3</sup>); NIOSH REL TWA 120 ppm (350 mg/m<sup>3</sup>); NIOSH REL CL 610 ppm (1800 mg/m<sup>3</sup>); IDLH 1500 ppm.

**PERSONAL PROTECTION:** wear appropriate protective clothing (boots, gloves, aprons, etc.); use splash-proof safety goggles where liquid pentane may contact the eyes; wear

self-contained breathing apparatus operated in positive pressure mode; eye-wash fountains and showers should be provided within immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of by atomizing in a suitable combustion chamber; flush remaining pentane with large amounts of water but not into confined spaces such as sewers because of danger of explosion; store in a cool, dry location with adequate ventilation; outside storage is preferred; inside storage should be in a standard flammable liquids storage room or cabinet.

**REGULATORY INFORMATION:** F2; T30-e10; T120-d10; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a gasoline additive for automotive, aviation and farm equipment; used in solvent extraction processes, as a general laboratory solvent, and as a medium solvent for polymerization reactions; used in the synthesis of amyl chlorides for intermediates in manufacture of paint, lacquer solvents, hydraulic fluids, paint removers, and miscellaneous petrochemicals; used in the synthesis of polychlorocyclopentanes as intermediates in manufacture of fire-resistant polyester resins and paints, dye intermediates, and plasticizers; use as a heat-exchange medium, a component of lighter fluids and blow-torch fuel, and in the manufacture of polystyrene beads for styrofoam production.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14; 16.

## 2-PENTANONE (CH<sub>3</sub>COCH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>, 86.15)

**CAS/DOT IDENTIFICATION #:** 107-87-9/UN1249

**SYNONYMS:** ethyl acetone, methyl propyl ketone, mpk.

**PHYSICAL PROPERTIES:** colorless to water-white liquid; fruity, ethereal odor; miscible with alcohol and ether; slightly soluble in water; MP (-78°C, -108°F); BP (102°C, 215.6°F); DN (0.809 g/mL liquid at 20°C); LSG (0.81 at 20°C); ST (23.25 mN/m at 25°C); VS (0.473 cP at 25°C); CP (184.1 J/K-mol liquid at 25°C); HV (38.4 kJ/mol at 25°C); VD (3.0); REL DN vapor/air mixture (1.03 at 20°C); VP (27 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with oxidizing materials; FP (7°C, 45°F); LFL/UFL (1.5%, 8.2%) AT (505°C, 941°F); HC (-2.8796 x 10<sup>9</sup> J/kmol); HF (-297.3 kJ/mol liquid at 25°C); H<sub>f</sub> (10.6 kJ/mol at 196.2K); IR (1.3895 at 20°C).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; very dangerous fire hazard; NFPA rating Health 2, Flammability 3, Reactivity 0; vapor mixes well with air, easily forming explosive mixtures; electrostatic charges can be generated as a result of flow, agitation, etc; reacts violently with strong oxidants, strong bases, amines, and isocyanates; mixtures with bromine trifluoride may explode during evaporation; heating to decomposition emits carbon monoxide and carbon dioxide; use dry powder, alcohol-resistant foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, dizziness, headache, drowsiness, dullness, sore throat, nausea, irritates respiratory passages, eyes, and skin); contact (dry skin, redness, pain); ingestion (abdominal pain, nausea, narcosis, coma).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; if breathing has stopped, provide respiratory support; in case of ingestion, rinse mouth and seek prompt medical attention.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 1500 ppm; toxic effect: eye, central nervous system, gastrointestinal tract; oral-unspecified LD<sub>50</sub> 3700 mg/kg; inhalation-unspecified LC<sub>50</sub> 22g/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; irritation to tissues or mucous membranes; headache; dizziness; drowsiness; dullness; cough; sore throat; abdominal pain; nausea; narcosis; coma.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact with skin may cause dermatitis; mutation data has been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm (705 mg/m<sup>3</sup>); ACGIH TLV STEL 250 ppm (881 mg/m<sup>3</sup>); OSHA PEL TWA 200 ppm (700 mg/m<sup>3</sup>); NIOSH REL TWA 150 ppm (530 mg/m<sup>3</sup>); IDLH 1500 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment and lighting; appropriate respirators are needed in areas where exposure would be above the permissible exposure level or IDLH conditions; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; collect spilled liquid in sealable containers or absorb with materials (e.g., dry earth, sand or vermiculite), and place in chemical waste containers; flush remaining material with large amounts of water but not into confined spaces such as sewers because of possibility of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; store in a cool, dry location; maintain adequate ventilation; store in tightly closed containers; containers should be grounded to prevent build-up of electrostatic charges; compressed air should not be used for filling, discharging, or handling; fireproof if in building; separate from oxidants, bromine trifluoride and strong bases.

**REGULATORY INFORMATION:** Al; CAL; DOT hazard class/division (3); label (flammable liquid).

**OTHER COMMENTS:** commercial material consists of a mixture of methyl propyl and diethyl ketones in a 3:1 approximate ratio and contains at least 97% of these ketones, the remainder being sec-amyl alcohol; may be utilized as a solvent, a substitute for diethyl ketone, and as a flavoring agent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**PERCHLOROETHYLENE (Cl<sub>2</sub>C=CCl<sub>2</sub>, 165.82)**

**CAS/DOT IDENTIFICATION #:** 127-18-4/UN1897

**SYNONYMS:** carbon bichloride, carbon dichloride, ethylene tetrachloride, tetracap, tetrachloroethene, tetrachoroethylene, 1,1,2,2-tetrachloroethylene.

**PHYSICAL PROPERTIES :** colorless liquid; mild, chloroform-like odor; miscible with alcohol, ether, chloroform, and benzene; insoluble in water; MP (-22°C, -8°F); BP (121°C, 250°F); DN (1.6311 g/mL at 15°C); LSG (1.62); VS (0.845 mPa-s at 25°C); CP (143.4 J/K-mol liquid at 25°C); HV (39.68 kJ/mol at 25°C); VD (5.83); VP (15.8 mmHg at 22°C); OT (4.68 ppm).

**CHEMICAL PROPERTIES:** extremely stable; resists hydrolysis; reacts with chemically-active metals such as lithium, beryllium, and barium; reaction with strong oxidizers, caustic soda, sodium hydroxide, and potash; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible liquid; NFPA rating Health 2, Flammability 0, Reactivity 0; no flash point in conventional closed tester; reacts violently with barium, beryllium, lithium, dinitrogen tetroxide, and sodium hydroxide; decomposes in a fire to hydrogen chloride and phosgene; use water spray, fog or suitable agent for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (anesthetic effects, conjunctiva irritation, hallucinations, distorted perceptions, pulmonary changes, coma); ingestion (irritates the gastrointestinal tract, nausea, vomiting, abdominal pain, diarrhea); contact (dermatitis, severe eye and skin irritation).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLO 96ppm/7H; toxic effect: eye, central nervous system, peripheral nervous system effects; inhalation-man TCLO 600 ppm/10M; toxic effect: eye, central nervous system; inhalation-man LDLo 2857 mg/kg; toxic effect: central nervous system, pulmonary system; dns-human lung 100mg/L.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; nausea; vertigo; dizziness; headache; flushing of face and neck; incoordination; drowsiness; skin erythema (redness); anesthetic effects; hallucinations; distorted perceptions; kidney dysfunction; dermatitis; coma; death.

**CHRONIC HEALTH RISKS:** cardiac arrhythmia; liver damage; kidney effects; menstrual disorders; spontaneous abortions; neurological effect; impairment of intellectual function; impairment of memory and concentration; increased risk of leukemia in children; EPA Group B2/C: probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50ppm; ACGIH TLV STEL 200 ppm; OSHA PEL TWA 100 ppm; OSHA PEL CL 200 ppm; NIOSH REL TWA minimize workplace exposure; IDLH 150 ppm.

**PERSONAL PROTECTION:** wear full protective clothing (rubber boots, aprons, sleeves, gas-tight suit, etc.); wear chemical resistant gloves; wear chemical safety goggles and positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible in non-combustible materials such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite, and place in a secured, sanitary landfill; store in a cool, dry location with adequate ventilation; separate from chemically active metals; isolate from open flames and combustibles.

**REGULATORY INFORMATION:** R2-53; R3; Reportable Quantity (RQ): 100 lbs (45.4 kg); Sfl; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used in the dry cleaning industry; used in textile processing; used as a degreasing agent; chemical intermediate in production of fluorocarbons; used in electrical transformers as an insulating fluid and cooling gas.

**KEY REFERENCES:** 3; 4; 5; 6; 10 ;12; 13; 14; 19.

### **PERCHLOROMETHYL MERCAPTAN (Cl<sub>3</sub>CSCI, 185.87)**

**CAS/DOT IDENTIFICATION #:** 594-42-3/UN1670

**SYNONYMS:** pcm, pmm, trichloromethane sulfenyl chloride, trichloromethanethiol, trichloromethylsulfenyl chloride, trichloromethylsulfur chloride

**PHYSICAL PROPERTIES :** pale-yellow, oily liquid; unbearable, foul-smelling odor; insoluble in water; MP (NA); BP (149°C, 300°F); DN (1.722 g/mL at 0°C); LSG (1.69); VD (6.414); VP (65 mmHg at 20°C); OT (< permissible exposure limit 0.1 ppm).

**CHEMICAL PROPERTIES:** noncombustible liquid; corrosive to most metals; subject to the action of oxidizing agents; reducing agents, chlorine, etc.; forms hydrogen chloride, sulfur and carbon dioxide on contact with water; can react vigorously with alkalis, amines, and hot iron; mildly decomposed by moist air; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible liquid, but will support combustion; NFPA rating (NA); contact with hot iron causes formation of toxic carbon tetrachloride vapor; contact with hot water causes formation of hydrochloric acid, sulfur and carbon dioxide; decomposes rapidly at elevated temperatures to give carbon tetrachloride and sulfur monochloride; may decompose rapidly on contact with alkalis and amines; will attack some forms of plastics, rubber, and coatings; hazardous decomposition products include carbon tetrachloride, sulfur monochloride, hydrogen chloride, sulfur dioxide, and carbon monoxide; use alcohol foam, dry chemical, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, irritates eyes, nose, throat, and lungs); skin contact (breathing difficulty, kidney damage, liver damage, death).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; lacrimation; coughing; severe breathing difficulty; deep breath pain; nausea; vomiting; pallor; skin irritation.

**CHRONIC HEALTH RISKS:** liver damage; lung damage; damage to the kidneys; anuria; acidosis; tachycardia; coarse rales.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; OSHA PEL TWA 0.1 ppm (0.8 mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.8 mg/m<sup>3</sup>); IDLH 10 ppm.

**PERSONAL PROTECTION:** wear appropriate protective clothing (boots, gloves, aprons, etc.); use splash-proof safety goggles where liquid perchloromethyl mercaptan may contact the eyes; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible with materials such as dry earth, sand, or vermiculite.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; dissolve in a flammable solvent, such as alcohol, and burn in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers, reducing agents, and chemically active metals.

**REGULATORY INFORMATION:** S<sub>2</sub>; S<sub>3</sub>; A<sub>1</sub>; A<sub>5</sub>; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as an organic intermediate; used in chemical synthesis for agricultural and dye chemicals.

**KEY REFERENCES:** 4; 5; 6; 7; 16.

### PERCHLORYL FLUORIDE (ClFO<sub>3</sub>, 102.45)

**CAS/DOT IDENTIFICATION #:** 7616-94-6/UN3038

**SYNONYMS:** chlorine fluoride oxide, chlorine oxyfluoride, trioxychlorofluoride.

**PHYSICAL PROPERTIES :** colorless, non-corrosive gas; characteristic, sweet odor; shipped as a liquefied compressed gas; negligible solubility in water; MP (-147.8°C, -234°F); BP (-46.7°C, -52°F); DN (1.434 g/mL liquid at 20°C); LSG (1.41 at 25°C); CP (0.229 cal/g/°C liquid at -40°C, 0.290 cal/g/°C liquid at 50°C); HV (4.6 kcal/mol); VD (3.64); VP (10.5 atm at 20°C); OT (10 ppm).

**CHEMICAL PROPERTIES:** nonflammable gas; heat may contribute to instability; strong oxidizing agent; will attack some forms of plastics, rubber and coatings; does not corrode base metals when anhydrous; demonstrates the greatest resistance to electrical breakdown known for any gas; reacts vigorously with reducing agents, alcohols and amines. FP (NA); LFL/UFL (NA); AT (NA); HF (-5.12 kcal/mol gas at 25°C); T<sub>c</sub> (95.2°C, 203.4°F); P<sub>c</sub> (53 atm, 40,280 mmHg).

**EXPLOSION and FIRE CONCERNS:** nonflammable, but will support combustion; NFPA rating (NA); powerful oxidizer; moderately explosive; contact with combustible materials, strong bases, amines, and finely divided metals may cause fires and explosions; yields explosive products on contact with readily oxidizable materials such as hydrogen sulfide, charcoal, sawdust and lampblack; reacts violently with finely divided organic materials; potentially explosive reactions with combustible gases or vapors, benzene and aluminum trichloride, calcium acetylide, potassium cyanide, potassium thiocyanate, sodium iodide, hydrocarbons, nitrogen oxide, sulfur dichloride, and vinylidene chloride; containers may explode when heated above 500°C (932°F); heating to decomposition emits hydrogen fluoride and chlorine; use water or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory system, cyanosis, alveolar edema, pneumonitis, severe headache, dizziness, nausea, unconsciousness); contact (skin burns, liquid may cause frostbite).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of respiratory system; bluish discoloration of skin; drowsiness; dizziness; rapid heart beat; nausea; headache; shortness of breath; weakness; pulmonary edema; bronchopneumonia; loss of consciousness; skin burns.

**CHRONIC HEALTH RISKS:** destruction of red blood cells; anemia; anorexia; target organs: skin, respiratory system, blood.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 3 ppm; ACGIH TLV STEL 6 ppm; OSHA PEL TWA 3 ppm (13.5 mg/m<sup>3</sup>); NIOSH REL TWA 3 ppm (14 mg/m<sup>3</sup>); NIOSH REL STEL 6 ppm (28 mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and face shields; use splash-proof safety goggles; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of leak to disperse gas; stop flow of gas if possible; if source of leak is a cylinder, remove cylinder to a safe place in open air, and allow cylinder to empty.

**DISPOSAL AND STORAGE METHODS:** dissolve liquid perchloryl fluoride in a more flammable solvent (such as alcohol) and atomize in a suitable combustion chamber equipped with effluent gas cleaning device; store in a cool, dry location with adequate ventilation; usually stored in cylinders as liquid under pressure; do not bring in contact with alcohols, reducing agents, etc.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, oxidizer).

**OTHER COMMENTS:** used in organic synthesis in oxidation, ammonolysis, perchlorylation, etherification, and fluorination; used as an oxidant in rocket fuels, fuels used in cutting and welding, torches and chemical machinery; used as an insulator for high voltage systems; miscellaneous uses include the manufacture of fuel cells, a gaseous dielectric for transformers, explosives, and metal processing.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 16.

### **PERLITE (NA, varies)**

**CAS/DOT IDENTIFICATION #:** 93763-70-3/none

**SYNONYMS:** expanded perlite.

**PHYSICAL PROPERTIES :** amorphous material consisting of fused sodium potassium aluminum silicate; light-gray to glassy-black solid; odorless; expands when finely grounded and heated; expanded (high temperature treated) perlite is a fluffy, white particulate; poor solubility in water; MP (>1093°C, >2000°F); BP (unknown); DN (2.2-2.4 g/cm<sup>3</sup> (crude), 0.05-0.3 g/cm<sup>3</sup> (expanded)); AVG DN (0.13); SG (2.2-2.4 (crude), 0.05-0.3 (expanded)); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** not combustible; no incompatibilities and reactivities reported; no hazardous decomposition products; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** none reported; in case of fire in the surroundings, all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (inhalation of fine dust and mist should be avoided; irritates eyes, skin, throat, and upper respiratory system).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; if breathing is difficult, remove to fresh air and provide oxygen; provide respiratory support if indicated.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory system; sore throat; cough; shortness of breath; wheezing.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg (total dust)/m<sup>3</sup> (when toxic impurities are not present); OSHA PEL TWA 15 mg (total dust)/m<sup>3</sup>; 5 mg (respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg (total dust)/m<sup>3</sup>; 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or disposable coveralls; use dust-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use positive pressure self-contained breathing apparatus; for extra personal protection, a P1 filter respirator for inert particles should be employed; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into covered containers; if appropriate, moisten first to prevent dusting and dispersion; carefully remove to a safe place for proper disposal.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an appropriate waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; keep away from food and feedstuffs.

**REGULATORY INFORMATION:** A1.

**OTHER COMMENTS:** slightly toxic by ingestion; negligible evaporation at 20°C; a nuisance-causing concentration for airborne particles can be reached quickly on spraying or dispersion.

**KEY REFERENCES:** 4; 5; 6; 14.

**PETROLEUM DISTILLATES** (a mixture of paraffins(C<sub>5</sub> to C<sub>13</sub>) that may contain a small amount of aromatic hydrocarbons, 100 (approximately)).

**CAS/DOT IDENTIFICATION #:** 8002-05-9/UN1255

**SYNONYMS:** aliphatic petroleum naphtha, petroleum ether (95-115°C), petroleum naphtha, rubber solvent.

**PHYSICAL PROPERTIES :** colorless, mobile liquid; odor-like gasoline and kerosene; has a fast evaporation rate and a narrow distillation range; does not solidify in the cold; miscible

with absolute alcohol, chloroform, benzene, ether, carbon tetrachloride carbon disulfide, and oils (except castor oils); not soluble in water; MP (data not available); BP (30-237.8°C, 86-460°F); DN/SG (0.63-0.66); VD (3.4 (approximately)); VP (40 mmHg (approximately) at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; can react vigorously with strong oxidizers; will attack some forms of plastics, rubber, and coatings; FP (-40 to -65.5°C, -40 to -86°F); LFL/UFL (1.1%, 5.9%); AT (288°C, 550°F).

**EXPLOSION and FIRE CONCERNS:** highly flammable liquid; NFPA rating Health 1, Flammability 4, Reactivity 0; vapors mixed with air explodes if ignited; flash back along vapor trail may occur; containers may explode in fire; contact with strong oxidizing agents may cause fire and explosions; toxic gases and vapors, such as carbon monoxide and carbon dioxide, may be released in a fire; use dry chemical, carbon dioxide, or alcohol foam for firefighting purposes; use water for cooling purposes only.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, lightheadedness, coughing, pulmonary edema, shortness of breath, irritates eyes, nose and throat); ingestion (abdominal pain, nausea, vomiting, diarrhea, loss of appetite, changes in menstrual cycle); contact (chemical pneumonitis, dry, cracked skin).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, seek immediate medical attention.

**HUMAN TOXICITY DATA:** parenteral-man TDLo 57 mg/kg; probable oral lethal dose (human) 0.5-5 g/kg, between 1 ounce and 1 pint (or 1 lb) for 70 kg person (150 lb).

**ACUTE HEALTH RISKS:** irritation to eyes, nose, and throat; irritation to mucous membranes; neurotoxic effects, including anesthesia, euphoria, abuse, vertigo, and limb numbness; signs of drunkenness; headache; dizziness; coughing; choking; gagging; dyspnea; nausea; vomiting; diarrhea; epigastric discomfort; loss of appetite; impairment of motor action; muscle weakness; chemical pneumonitis, with pulmonary edema and hemorrhagic frothy sputum; bacterial pneumonia may develop; indications of slight renal tubular effects were reported after exposure to rubber solvent; disturbances in menstrual cycle; disturbance of ovarian function; reduced estrogen level in the blood; bronchospasm; necrosis of bronchial, bronchiolar, and alveolar tissues; vascular thrombosis; residual small airway abnormalities; can cause reversible cerebral edema; fatty infiltration of the liver may occur; may cause myocarditis and myo-cardial infarction; very high concentrations can cause convulsions and death.

**CHRONIC HEALTH RISKS:** a rubber solvent induced chromosomal aberrations in human whole-blood cultures; repeated exposure can damage the nervous system, including headache, fatigue, poor concentration, emotional instability, impaired memory and other intellectual functions; chronic neurotoxic effects include motor polyneuropathy; prolonged contact can cause drying and cracking of skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 300 ppm (1350 mg/m<sup>3</sup>); OSHA PEL TWA 500 ppm (2000 mg/m<sup>3</sup>); NIOSH REL TWA 350 mg/m<sup>3</sup>; NIOSH REL CL 1800 mg/m<sup>3</sup>; IDLH 1100 ppm (based on 10% of lower explosive limit (LEL) for safety considerations).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, solvent-resistant gloves, lab coat, apron or coveralls; nitrile and neoprene rubbers or polyvinyl alcohol is recommended as protective materials; wear splash-proof chemical goggles when working with liquid; enclose operations and use local exhaust ventilation at the site of chemical

release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; use explosion-proof electrical equipment and non-sparking tools; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; absorb liquids with dry earth, sand or other noncombustible material and transfer to sealed containers; flush remaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion; a vapor suppressing foam may be used to reduce vapors; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquids in dry earth, sand or vermiculite, and place in a secured, sanitary landfill; large quantities may be disposed of by atomizing in a suitable combustion chamber; store in a cool, dry area; use only with adequate ventilation; store in tightly closed containers; metal containers involving the transfer of 5 gallons or more should be bonded and grounded; separate from strong oxidizers (such as chlorine, bromine and fluorine).

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as solvents in rubber industry during manufacture of waterproof cloth, shoe adhesives, and rubber tires; used in preparation of paint, varnish, and lacquer as solvents, diluents, or thinners; utilized during dry cleaning operations; use as an extractant.

**KEY REFERENCES:** 3; 4; 5; 6; 15; 16.

## PHENOL (C<sub>6</sub>H<sub>5</sub>OH, 94.12)

**CAS/DOT IDENTIFICATION #:** 108-95-2/UN1671 (solid), UN2312 (molten), UN2821 (solutions).

**SYNONYMS:** carboic acid, hydroxybenzene, monohydroxybenzene, oxybenzene, phenic acid, phenyl hydroxide, phenylic acid, phenylic alcohol.

**PHYSICAL PROPERTIES :** colorless to light-pink, crystalline solid; aromatic odor, somewhat sweet and acrid; liquefies by mixing with about 8% water; light pink, watery liquid if wet; reddens on exposure to air and light; sharp, burning taste; very soluble in alcohol, chloroform, ethyl ether, glycerol, carbon disulfide, petrolatum, aqueous alkali hydroxides, carbon tetrachloride, acetic acids, volatile and fixed oils; practically insoluble in petroleum ether; soluble in water; MP (41°C, 106°F); BP (182°C, 358°F); DN (1.0576 g/mL at 20°C); SG (1.06); ST (39.88 dynes/cm at 30°C); VS (12.7 cP at 18.3°C, 3.49 cP at 50°C, 1.26 cP at 90°C); CP (127.4 J/mole-K crystal at 25°C); HV (45.69 kJ/mole at 181.8°C); VD (3.24); VP (0.357 mmHg at 20°C, 1mmHg at 40°C); OT (0.006-0.024 ppm, 0.022-0.094 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** combustible solid; light sensitive; reacts with aluminum chloride in the presence of nitromethane or nitrobenzene; hot phenol reacts with metals and oxidizers; reacts vigorously with calcium hypochlorite and acids; FP (79°C, 175°F); LFL/UFL (1.8%, 8.6%); AT (715°C, 1319°F); HC (3053.5 kJ/mole at 25°C); HF (-165.1 kJ/mole crystal at 25°C, -96.4 kJ/mole gas at 25°C); H<sub>f</sub> (11.3 kJ/mole at 314.0K).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 3, Flammability 2, Reactivity 0; reacts explosively with aluminum chloride and nitromethane at 110°C and 100bar; explosive reactions with formaldehyde, peroxydisulfuric acid, peroxymonosulfuric acid, and sodium nitrate and heat; reacts violently with aluminum chloride and nitroben-

zene at 120°C, sodium nitrate and trifluoroacetic acid, and butadiene; reacts strongly with oxidizing materials; toxic and irritating vapors are generated when heated to decomposition; use water spray, dry chemical, alcohol resistant foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** absorption (damage to kidneys, liver, pancreas, and spleen; edema of the lungs); ingestion (burning of mouth and throat, abdominal pain, corrosion of lips, mouth, throat, esophagus, and stomach; gangrene); contact (irritation of eyes, nose and throat; skin burns, dermatitis; ochronosis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with large amounts of soap and water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 14g/kg; oral-human LDLo 140mg/kg; oral-infant LDLo 10mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; skin burns; dermatitis; froth at mouth and nose; pulmonary edema; cyanosis; tremor; convulsions; twitching; burning of mouth and throat; lesions in mouth, esophagus and stomach; abdominal pain; low-weight; weakness; weak pulse; reduced blood pressure; death due to respiratory failure.

**CHRONIC HEALTH RISKS:** vomiting; diarrhea; difficulty swallowing; excessive salivation; anorexia; weight loss; headache; fainting; vertigo; muscle aches and pain; mental disturbances; weakness; dark urine; damage to liver and kidney; elevated levels of liver enzymes; dermal inflammation and necrosis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (skin); OSHA PEL TWA 5 ppm (19mg/m<sup>3</sup>(skin)); NIOSH REL TWA 5 ppm (19mg/m<sup>3</sup>(skin)); NIOSH REL CL 15.6 ppm (60 mg/m<sup>3</sup>/15M); IDLH 250 ppm.

**PERSONAL PROTECTION:** wear boots, rubber apron, and chemical-resistant gloves; wear positive pressure self-contained breathing apparatus; wear chemical safety goggles.

**SPILL CLEAN-UP:** approach release from upwind; flush spill with flooding quantities of water; neutralize with caustic acid solution and isolate for proper disposal; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** solutions of 1% phenol may be recovered by steam stripping, distillation, or carbon adsorption; dilute large amounts with flooding quantities of water and feed to sewage organisms; cautiously ignite small amounts; store in a cool, dry location; separate from oxidizers and acute fire hazards.

**REGULATORY INFORMATION:** CA2; R3; R4; R5; R6; R8; R9; U waste # (U188); Reportable Quantity (RQ): 1000lbs (454 kg); Sf1; Sf2; Sf3; CW1; CW2; CW3; CW4; CW5; T120-a; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a general disinfectant; many other medical uses include throat lozenges, mouthwashes, ear and nose drops; used in the production of industrial organic compounds and dyes; used as a chemical intermediate for caprolactam, pentachlorophenol, plasticizers, and medicinals.

**KEY REFERENCES:** 3; 4; 5; 6; 8; 9; 10; 11; 12; 13; 14; 19.

**p-PHENYLENE DIAMINE (C<sub>6</sub>H<sub>4</sub>(NH<sub>2</sub>)<sub>2</sub>, 108.16)**

**CAS/DOT IDENTIFICATION #:** 106-50-3/UN1673

## 830 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**SYNONYMS:** p-aminoaniline, 4-aminoaniline, p-benzenediamine, 1,4-benzenediamine, p-diaminobenzene, 1,4-diaminobenzene, 1,4-phenylenediamine.

**PHYSICAL PROPERTIES :** white to slightly red crystalline solid; oxidizes on standing in air to purple and black; soluble in alcohol, chloroform, and ether; freely soluble in water; MP(146°C, 295°F); BP (267°C, 513°F); SG (greater than 1); VD (3.72); VP (< 1 mmHg at 20°C); OT (NA).

**CHEMICAL PROPERTIES:** combustible solid; hazardous polymerization will not occur; affected by light; heat and light will contribute to instability; reacts vigorously with strong oxidizers; FP (155.5°C, 312°F); LFL/UFL (NA); AT (NA); HC (NA); HF (3.1 kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating (NA); contact with strong oxidizers may cause fires and explosions; toxic gases and vapors, such as carbon monoxide and oxides of nitrogen, may be released in a fire; use water spray, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates the larynx and pharynx); skin absorption (vertigo, anemia, gastritis, sensitization dermatitis, death).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water immediately; induce vomiting if conscious.

**HUMAN TOXICITY DATA:** skin-human 250mg/24H; toxic effect: mild irritation effects; oral-man TDLo 71mg/kg.

**ACUTE HEALTH RISKS:** irritation of pharynx and larynx; vertigo; tremors; gastritis; renal failure; eye irritation; lacrimation; convulsions; coma.

**CHRONIC HEALTH RISKS:** asthma; anemia; aplastic anemia; allergies; exfoliative dermatitis; eczema of the eyelids; fatal liver damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.1 mg/m<sup>3</sup>(skin); IDLH 25 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and eight-inch minimum face shields; use dust-and splash-proof safety goggles; wear self-contained breathing apparatus operated in a positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper or other suitable material, and place in an appropriate container and cautiously ignite in open areas; dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber equipped with appropriate effluent gas cleaning device.

**DISPOSAL AND STORAGE METHODS:** package in paper or other flammable material and burn in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; keep well closed and protected from light; separate from strong oxidizers.

**REGULATORY INFORMATION:** CA2; R3; R5; Reportable Quantity (RQ): 5000 lbs. (2270 kg); S1; S3; T120-a; T799-3300; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used in dye and dyestuff intermediates for hair, fur, leather, cotton, and synthetics; used in accelerating vulcanization, as an antioxidant, and stabilizer; used in the preparation of antioxidants for petroleum fuels; also used in the preparation of grease thickeners, electrical insulators, and rust removers; useful as a catalyst and as an analytical reagent; use in preparation of epoxy resins, synthetic fibers, heat-resistant polymers, and coatings for leather, paper, and textiles.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 12; 16.

### **PHENYL ETHER, VAPOR (C<sub>6</sub>H<sub>5</sub>OC<sub>6</sub>H<sub>5</sub>, 170.22)**

**CAS/DOT IDENTIFICATION #:** 101-84-8/none

**SYNONYMS:** biphenyl oxide, diphenyl ether, diphenyl oxide, 1,1'-oxybisbenzene, phenoxybenzene, phenyl oxide.

**PHYSICAL PROPERTIES :** colorless, crystalline solid or liquid depending on temperature; geranium-like odor; insoluble in water; soluble in alcohol, benzene, ether, and glacial acetic acid; MP (28°C, 82°F); BP (259°C, 498°F); DN (1.075 g/mL liquid at 20°C); LSG (1.08); ST (26.75 mN/m at 25°C); VS (no information found); CP (216.6 J/K-mol crystal at 25°C); HV (66.9 kJ/mol at 25°C); VD (5.86); VP (0.0225 mmHg at 25°C); OT (0.01 ppm).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; will attack some forms of plastics, rubber, and coatings; can react with oxidizing materials; FP (115°C, 239°F); LFL/UFL (0.7%, 6.0%); AT (618°C, 1144°F); HC (-5.8939 x 10<sup>9</sup> J/kmol); HF (-32.1 kJ/mol crystal at 25°C, 52.0 kJ/mol gas at 25°C); H<sub>f</sub> (17.22 kJ/mol at 300.02K).

**EXPLOSION and FIRE CONCERNS:** combustible solid and liquid; NFPA rating Health 1, Flammability 1, Reactivity 0; explosive vapor-air mixtures may be formed above flash point; contact with strong oxidizing agents may cause fires and explosions; incompatible with strong oxidizers and chlorosulfonic acid; carbon dioxide and carbon monoxide may form when heated to decomposition; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (severe nausea, vapor can irritates eyes, nose and upper respiratory tract); skin contact (brief contact may have no effect; repeated contact may cause irritation, redness, itching and pain); eye contact (irritation, redness, pain); ingestion (some injury to liver, kidneys, spleen, thyroid and intestinal tract (based on animal studies)).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; in case of ingestion, induce vomiting; get immediate medical attention..

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and skin; irritation to upper respiratory tract; severe nausea; may cause irritation of the gastrointestinal tract; injury to the kidneys, liver, spleen, thyroid and intestinal tract.

**CHRONIC HEALTH RISKS:** prolonged contact may cause irritation, redness, itching and pain; chronic exposure may affect kidneys and liver.

## 832 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm(vapor); ACGIH TLV STEL 2 ppm (vapor); OSHA PEL TWA 1 ppm (7 mg/m<sup>3</sup>)(vapor); NIOSH REL TWA 1 ppm (7 mg/m<sup>3</sup>)(vapor); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or full face shield; use a closed system of local exhaust ventilation to control emissions at the source and to prevent dispersion into general work area; use non-sparking tools and equipment; if the exposure limit is exceeded, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; clean-up solids spills without dispersing dust into the air; moisten spill with water to reduce airborne dust and prevent scattering; pick up spill and place in a closed container for proper disposal; absorb liquid spills with an inert material (e.g., dry earth, sand, vermiculite), and place in a chemical waste container; flush remaining liquid with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of by dissolving in appropriate solvent and atomizing in a suitable combustion chamber; store in a cool, dry location; use only with adequate ventilation; keep in a tightly closed container; protect against physical damage; store separately from reactive or combustible materials; isolate from incompatible substances and keep out of direct sunlight.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a high temperature heat transfer medium; used as an odorant in perfuming soaps; useful in organic synthesis, resulting in epoxy resins, high temperature lubricants, specialty plasticizers, varnishes, artificial sweeteners, fire retardants, and adhesives.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14; 16.

**PHENYL ETHER-BIPHENYL MIXTURE, VAPOR (C<sub>6</sub>H<sub>5</sub>OC<sub>6</sub>H<sub>5</sub>/C<sub>6</sub>H<sub>5</sub>C<sub>6</sub>H<sub>5</sub>, 166 (average))**

**CAS/DOT IDENTIFICATION #:** NA/NA

**SYNONYMS:** diphenyl oxide-diphenyl mixture, dowtherm<sup>®</sup> A.

**PHYSICAL PROPERTIES :** colorless to straw-colored liquid; darkens on use; disagreeable, aromatic odor; a solid below 54°F; mixture contains 75% phenyl ether and 25% biphenyl; practically insoluble in water; MP (12°C, 54°F); BP (257°C, 495°F); DN (1.05-1.07 g/mL); LSG (1.06 at 25°C); VD (5.7 average); VP (0.08 mmHg at 25°C); OT (0.1 - 1 ppm).

**CHEMICAL PROPERTIES:** heat may contribute to instability; will attack some forms of plastics, rubber, and coatings; reacts vigorously with strong oxidizers; FP (124°C, 255°F); LFL/UFL (0.5%, 6.2% at 500°F); AT (621°C, 1150°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating (NA); contact with strong oxidizing agents may cause fires and explosions; very corrosive; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, and skin, may also cause nausea).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with large amounts of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human T<sub>CLo</sub> 3 ppm; toxic effect: irritant effects on the skin, eyes, or mucous membranes.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, and skin; nausea.

**CHRONIC HEALTH RISKS:** no chronic systemic effects have been reported in humans; can cause dermatitis on prolonged exposure; however, persons with pre-existing skin disorders may be more susceptible to its effects; may cause exacerbation of symptoms in persons with impaired pulmonary function.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm vapor; OSHA PEL TWA 1 ppm (7 mg/m<sup>3</sup>); NIOSH REL TWA 1 ppm (7 mg/m<sup>3</sup>); IDLH 10 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, aprons, and eight inch minimum face shields; use dust- and splash-proof safety goggles; self-contained breathing apparatus operated in positive pressure mode is recommended.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; large quantities may be dissolved in a more flammable solvent and atomized in a suitable combustion chamber.

**DISPOSAL AND STORAGE METHODS:** dissolve in an appropriate solvent and atomize in a suitable combustion chamber equipped with effluent gas cleaning device; absorb as much as possible in noncombustible materials such as dry earth, sand, vermiculite or silica gel, and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers.

**REGULATORY INFORMATION:** no information found.

**OTHER COMMENTS:** use in chemical, petroleum, and nuclear industry; a high-transfer medium used in heating and cooling processes, marked as Dowtherm<sup>®</sup>A, Termax, Diphyl, and Gilotherm; used as a dyeing aid for printing and dyeing polyester textiles.

**KEY REFERENCES:** 4; 5; 6; 14; 16.

## **PHENYL GLYCIDYL ETHER (C<sub>9</sub>H<sub>10</sub>O<sub>2</sub>, 150.19)**

**CAS/DOT IDENTIFICATION #:** 122-60-1/none

**SYNONYMS:** 1,2-epoxy-3-phenoxypropane, 2,3-epoxypropylphenyl ether, glycidyl phenyl ether, pge, phenoxy methyloxirane, phenyl-2,3-epoxypropyl ether.

**PHYSICAL PROPERTIES:** colorless liquid; exists as a solid; below 38°F (3.3°C); has a characteristic odor; somewhat soluble in water; MP (3.5°C, 38.3°F); BP (245°C, 473°F); DN (1.11 g/mL liquid at 20°C); LSG (1.11); VD (5.2); REL DN vapor/air mixture (1.00 at 20°C); VP (0.01 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; reacts with strong oxidants, acids and bases;

## 834 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

FP (>79°C, >174°F); LFL/UFL (1.1%, unknown); AT (unknown); HC (data not available in the literature).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; may form explosive vapor/air mixtures above 79°C; can be presumed to form explosive peroxides; incompatible with amines, strong oxidants, acids and bases; decomposes on burning, producing toxic gases and vapors (such as carbon monoxide and carbon dioxide); use powder, water, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dullness, irritates eyes, skin and respiratory tract); skin absorption (narcotic effects, skin sensitization, unconsciousness); contact (liquid defats skin, may cause dermatitis); ingestion (confusion, dizziness, drowsiness, dullness).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; flush affected areas of skin with large amounts of soap and water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, rinse mouth and give plenty of water to drink; seek medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory system; dizziness; confusion; drowsiness; dullness; narcosis; exposure could cause lowering of consciousness.

**CHRONIC HEALTH RISKS:** repeated or prolonged contact may cause skin sensitization and dermatitis; liquid may cause defatting of skin; substance is possibly carcinogenic to humans (has caused nasal cancer in animals); experimental reproductive effects have been reported; possible hematopoietic effects may occur.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (0.6 mg/m<sup>3</sup>); NOSHA REL TWA 10 pm (60 mg/m<sup>3</sup>); NIOSH REL CL 1 ppm/15M (6 mg/m<sup>3</sup>/15M), potential occupational carcinogen; IDLH 100 ppm, potential occupational carcinogen.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles or face shield; above 79°C, a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; explosion-proof electrical equipment is required; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; collect spilled liquid in sealable containers or absorb with non-combustible materials (e.g., dry earth, sand or vermiculite), and place in chemical waste container; wash away remainder with plenty of water; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb spilled liquid in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; maintain adequate ventilation; fireproof if in building; separate from strong oxidants, strong bases, and strong acids.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (NA); label (NA).

**OTHER COMMENTS:** prior to distillation, this substance should be examined for peroxides and eliminated if found; the harmful effect of this chemical may be enhanced by use of alcoholic beverages; has been used as a chemical intermediate in organic synthesis.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

### **PHENYLHYDRAZINE (C<sub>6</sub>H<sub>5</sub>NHNH<sub>2</sub>, 108.16)**

**CAS/DOT IDENTIFICATION #:** 100-63-0/UN2572

**SYNONYMS:** hydrazine-benzene, hydrazinobenzene, monophenylhydrazine.

**PHYSICAL PROPERTIES :** colorless to pale-yellow, oily liquid or crystals; faint aniline-like odor; becomes red-brown on exposure to air and light; slightly soluble in hot water; miscible with alcohol, ether, chloroform, and benzene; soluble in dilute acids; sparingly soluble in petroleum ether; MP (19.5°C, 67°F); BP (243.5°C, 470.3°F decomposes); DN (1.0978 g/mL at 20°C); LSG (1.10); CP (217.0 J/K-mol liquid at 25°C); VD (3.7); VP (1 mmHg at 71.8°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; turns yellow to dark red on exposure to air and light; forms a hemihydrate; hazardous polymerization will not occur; reacts with strong oxidizers; FP (88°C, 190°F); LFL/UFL (unknown); AT (174°C, 345°F); HF (141.0 kJ/mol liquid at 25°C); H<sub>f</sub> (16.4 kJ/mol at 292.7K).

**EXPLOSION and FIRE CONCERNS:** combustible solid, liquid and vapor; above 88°C, may form explosive vapor-air mixtures; NFPA rating Health 3, Flammability 2, Reactivity 0; contact with strong oxidizers may cause fire; reacts violently with lead dioxide; forms an explosive product on reaction with perchloryl fluoride; violent reaction with 2-phenylamino-3-phenyloxazirane; very dangerous; heating to decomposition produces carbon dioxide, carbon monoxide, and toxic fumes of oxides of nitrogen; use water spray, alcohol foam, powder or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sore throat, coughing, labored breath, dizziness, bluish skin, faintness); skin contact (dry skin, redness, pain, may cause allergic skin reaction); skin absorption (symptoms parallel those toxic effects noted for inhalation and ingestion); eye contact (redness, pain, destructive to eye tissue); ingestion (nausea, vomiting, diarrhea, abdominal pain, weakness, vertigo, jaundice, hemolysis of red blood cells).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; if not breathing, provide artificial respiration; in case of ingestion, give plenty of water to drink; get immediate medical attention..

**HUMAN TOXICITY DATA:** no toxicity data available in humans; investigated as a tumorigen, mutagen, and reproductive effector; this compound has caused both birth defects and damage to reproductive system in laboratory animals.

**ACUTE HEALTH RISKS:** corrosive to respiratory tract; sore throat; coughing; labored breathing; dizziness; cyanosis (bluish skin); faintness; gastrointestinal disturbances; abdominal pain; nausea; vomiting; diarrhea; weakness; vertigo; hemolytic anemia (breakdown of red blood cells); kidney damage; injury to liver; jaundice; vascular thrombosis; destructive to eye tissue.

**CHRONIC HEALTH RISKS:** may produce blood effects, resulting in anemia; damage to the spleen, liver, kidneys, and bone marrow; contact dermatitis; skin sensitization; suspect cancer hazard.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm (0.44 mg/m<sup>3</sup>)(skin), category A3-animal carcinogen; OSHA PEL TWA 5 ppm (22 mg/m<sup>3</sup>)(skin); NIOSH REL CL 0.14 ppm (0.6 mg/m<sup>3</sup>/2H)(skin); IDLH 15 ppm.

**PERSONAL PROTECTION:** wear impervious clothing, including boots, gloves, lab coat, apron or coveralls; suitable material for personal protective equipment include vinyl coated, rubber or neoprene; use chemical safety goggles in combination with breathing protection; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if exposure limit is exceeded, use positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; if substance is melted, collect spilled liquid in sealable containers; absorb remaining liquid with an inert material (e.g., dry earth, sand, vermiculite), and remove to safe place; flush spill area with large amounts of water but not into confined spaces such as sewers because of danger of explosion; if substance is solid, sweep spilled substance into container and carefully remove to a safe place; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; manage whatever cannot be saved for recovery or recycling in an approved waste facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; protect against physical damage; keep away from sources of heat or ignition; store separately from sources of heat or ignition; store separately from reactive or combustible materials.

**REGULATORY INFORMATION:** T30-e10; T120-d10; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a chemical reagent for sugars, ketones, and aldehydes; used in the manufacture of dyestuffs and pharmaceuticals; useful in the manufacture of antipyrine and nitron (stabilizers for explosives).

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### **PHOSDRIN (C<sub>7</sub>H<sub>13</sub>O<sub>6</sub>P, 224.17)**

**CAS/DOT IDENTIFICATION #:** 7786-34-7/2783

**SYNONYMS:** 2-carbomethoxy-1-methylvinyl dimethylphosphate, 2-methoxycarbonyl-1-methylvinyl dimethylphosphate, mevinphos.

**PHYSICAL PROPERTIES :** colorless to yellow liquid; weak odor; commercial product is a yellow liquid mixture of the cis- and trans isomers; miscible with water, benzene, acetone, carbon tetrachloride, chloroform, ethyl and isopropyl alcohols, toluene and xylene; practically insoluble in hexane; MP (-56°C, -69°F); BP (325°C, 617°F at 760 mmHg); DN (1.25 g/mL at 20°C); LSG (1.25); VD (NA); VP (0.003 mmHg at 20°C); OT (NA).

**CHEMICAL PROPERTIES:** combustible liquid; will attack some forms of plastics, rubber and coatings; can react with strong oxidizers; FP (175°C, 347°F); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating (NA); contact with strong oxidizers may cause fires and explosions; corrosive to cast iron, some stainless steels and brass; decomposes vigorously when heated above 300°C (572°F) and will cause containers to burst; toxic gases and vapors, such as carbon monoxide and phosphoric acid mist, may be released in a fire; use carbon dioxide, dry chemical, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (tightness in the chest, wheezing due to bronchoconstriction, excessive bronchial secretion, laryngeal spasms, excessive salivation, cyanosis, miosis, aching in and behind the eyes, blurring of distant vision, tearing, rhinorrhea, front headache); skin absorption (localized sweating, muscular fasciculations, involuntary twitchings, paralysis, giddiness, confusion, ataxia, slurred speech, loss of reflexes, low blood pressure, irregular heart-beat, convulsions, coma); ingestion (nausea, vomiting, diarrhea, abdominal cramps, anorexia).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** oral-man TDLo 700µg/kg/28D; toxic effect: peripheral nervous system effects.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; tightness of the chest; wheezing ;bluish discoloration of the skin; small pupils; blurring of vision; lacrimation; headache; salivation; nausea; vomiting; abdominal cramps; diarrhea; loss of appetite; weakness; sweating; involuntary twitchings; paralysis of respiratory muscles; low blood pressure; cardiac irregularities; convulsions; coma.

**CHRONIC HEALTH RISKS:** depressed levels of cholinesterase activity in the serum and erythrocytes; anorexia; cardiovascular system effects; effects on the central nervous system; chronic skin disorders.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.01 ppm; ACGIH TLV STEL 0.03PPM (skin); OSHA PEL TWA 0.1 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.01 ppm (0.1 mg/m<sup>3</sup>); NIOSH REL STEL 0.03 PPM (0.3 mg/m<sup>3</sup>)(skin); IDLH 4 ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); use impervious clothing, gloves, and other protective clothing necessary to prevent any possibility of skin contact; use splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible in non-combustible materials such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite and dispose in sealed containers in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; separate from strong oxidizing agents; keep away from stainless steels, brass, and cast iron.

**REGULATORY INFORMATION:** F1; Reportable Quantity (RQ): 10 lbs (4.54kg); Sf1; Sf2; Sf3; CW1; CW2; A1; CAL.

**OTHER COMMENTS:** application as an insecticide on agricultural crops, fruits, and vegetables; used as an insecticide in sewage treatment plants.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 16.

### **PHOSGENE (COCl<sub>2</sub>, 98.91)**

**CAS/DOT IDENTIFICATION #:** 75-44-5/UN1076.

**SYNONYMS:** carbon oxychloride, carbonyl chloride, carbonyl dichloride, chloroformyl chloride, disphosgene.

**PHYSICAL PROPERTIES :** colorless, poisonous gas; odor of musty hay at low concentrations; sharp and pungent odor at high concentrations; fuming liquid below 47°F; very soluble in benzene, acetic acid, toluene, and most liquid hydrocarbons; soluble in chloroform; partly soluble in water; MP (-118°C, -180°F); BP (8°C, 46°F); DN (1.381 g/mL at 20°C); SG (1.38); ST (34.6 mN/m at 0°C, 15.9 mN/m at 46.1°C); CP (57.7 J/K-mol gas at 25°C); HV (6,224.3 kcal/gmol); VD (3.41); VP (568 mmHg at 0°C, 1215 mmHg at 20°C); OT (0.5 ppm).

**CHEMICAL PROPERTIES:** nonflammable gas; corrosive in presence of moisture; reacts with alkalis, ammonia, alcohols, and active metals; reacts slowly in water to form hydrochloric acid and carbon dioxide; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-219.1kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** noncombustible gas; NFPA rating Health 4, Flammability 0, Reactivity 1; hazardous reactions with aluminum, potassium, sodium, and lithium; reacts violently with sodium azide, isopropyl alcohol, tert-butyl azido formate, hexadiyn-1,6-diol, and hexfluoroisopropylideneamino lithium; emits toxic and corrosive fumes of carbon monoxide and chlorine when heated to decomposition or on contact with water or steam; use water spray or neutralize with sodium hydroxide or anhydrous ammonia for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation(choking, chest constriction, coughing, painful breathing, and bloody sputum); contact (severe skin and eye burns).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LC<sub>50</sub> 3200mg/m<sup>3</sup>; inhalation-human TCLo 25 ppm/30M; toxic effect: pulmonary system; inhalation-man LCLo 360mg/m<sup>3</sup>/30M.

**ACUTE HEALTH RISKS:** severe irritation of skin, eyes and mucous membranes; severe pulmonary edema; pneumonia; choking; constricted feeling in chest; coughing; breathing difficulty; bloody sputum; vomiting; cyanosis; pulmonary emphysema; death in high concentrations.

**CHRONIC HEALTH RISKS:** unknown; no permanent residual disability is known to occur in patients who recover from exposure to phosgene gas..

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; OSHA PEL TWA 0.1 ppm (0.4mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.4mg/m<sup>3</sup>); NIOSH REL CL 0.2 ppm 15M (0.8 mg/m<sup>3</sup>/15M); IDLH 2 ppm.

**PERSONAL PROTECTION:** wear rubberized outerwear when liquid phosgene is involved; wear chemical safety goggles and gastight suit; wear full face gas masks or self-contained breathing apparatus.

**SPILL CLEAN-UP:** allow gas spills to flow into a mixed solution of caustic soda and lime; keep in a fume hood, if possible; cover liquid spills with sodium bicarbonate, soda ash or lime; cautiously atomize mixture with spray water and transfer into large container of water; water will increase evaporation of spilled material.

**DISPOSAL AND STORAGE METHODS:** scrub with 20% caustic in countercurrent tower; do not burn unless absolutely necessary; store in a cool, dry location; outside storage is preferred.

**REGULATORY INFORMATION:** CA2; R4; P waste # (P095); Reportable Quantity (RQ): 10lbs (4.54 kg); Sf1; Sf2; Sf3; CW1; CW2; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, corrosive).

**OTHER COMMENTS:** used in the production of aniline dyes, isocyanates and acid chlorides; may be used in the manufacture of insecticides, in pharmaceutical industry, and in metallurgy; used in the preparation of many organic chemicals; use as a war gas.

**KEY REFERENCES:** 3; 4; 5; 6; 10; 11; 12; 13; 14; 19.

## PHOSPHINE (PH<sub>3</sub>, 34.0)

**CAS/DOT IDENTIFICATION #:** 7803-51-2/UN2199

**SYNONYMS:** hydrogen phosphide, phosphorated hydrogen, phosphorus hydride, phosphorus trihydride.

**PHYSICAL PROPERTIES :** colorless gas; odor of rotten fish; slightly soluble in ethyl ether and ethyl alcohol; insoluble in water; MP (-133°C, -207°F); BP (-88°C, -126°F); DN (1.492 g/mL); LSG (0.76); CP (37.1 J/K-mol gas at 25°C); HV (14.6 kJ/mol at 185.40K); VD (1.17); VP (>760 mmHg at 20°C).

**CHEMICAL PROPERTIES:** flammable gas; extremely weak base; burns with a luminous flame; forms the phosphide and liberates hydrogen when passed over heated metal; forms phosphonium salts when brought in contact with the halogen acids; reacts with air and halogens; FP (NA); LFL/UFL (1.6%, 98%); AT (100°C, 212°F); HC (NA); HF (5.4 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable gas; NFPA rating Health 4, Flammability 4, Reactivity 2; very dangerous fire hazard; pyrophoric; may ignite spontaneously on contact with air; may accumulate and explode in air without source of ignition; evolves hydrogen when passed over heated metal; flashback along vapor trail may occur; closed containers may rupture violently when heated; low ignition energy; reacts explosively with dichlorine oxide, silver nitrate, concentrated nitric acid, nitrogen trichloride, and oxygen; forms an explosive product with mercury (II) nitrate; reacts violently or ignites with air, boron trichloride, bromine, chlorine, iodine, nitrogen oxide, nitrogen trioxide, dinitrogen oxide, nitrogen trichloride, nitrous acid, potassium and ammonia, oxidants, and aqueous halogen solutions; decomposition emits highly toxic fumes of oxides of phosphorus; use water spray, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (lung irritation, pulmonary edema, heart dilation, weakness, vertigo, convulsions, coma); contact (muscle pain, chills, chest tightness).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 1000ppm.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; weakness; vertigo; nausea; vomiting; abdominal pain; thirst; chest pressure; breathing difficulty; muscle pain; chills; stupor; pulmonary edema; lung damage; substernal pain; headaches; fatigue; dizziness; cough with green sputum; convulsion; coma; death.

**CHRONIC HEALTH RISKS:** anemia; bronchitis; liver effects; gastrointestinal disturbances; visual disturbances; speech and motor impairment; increased blood density; jaundice; central nervous system depression; dilation of the heart.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.3 ppm; ACGIH TLV STEL 1 ppm; OSHA PEL TWA 0.3 ppm (0.4 mg/m<sup>3</sup>); OSHA PEL STEL 1 ppm; NIOSH REL TWA 0.3 ppm (0.4 mg/m<sup>3</sup>); NIOSH REL STEL 1 ppm (1 mg/m<sup>3</sup>); IDLH 50 ppm.

**PERSONAL PROTECTION:** wear special protective clothing and chemical-resistant gloves; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of leak to disperse gas; use water spray to cool and disperse vapors; if source of leak is a cylinder, remove leaking cylinder to a safe place in open air and allow cylinder to empty.

**DISPOSAL AND STORAGE METHODS:** disposed of by burning in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; outside storage is preferred; separate from acids, alkalis, and halogenated compounds.

**REGULATORY INFORMATION:** CA2; R4; R6; R8; P waste # (P096); Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf1; Sf2; Sf3; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, flammable gas).

**OTHER COMMENTS:** used as a fumigant; used as a doping agent for n-type semiconductors; employed in the synthesis of flame retardants for cotton fabrics; use as a polymerization inhibitor and as a catalyst for condensation.

**KEY REFERENCES:** 1; 3; 4; 5; 6; 8; 9; 10; 12; 13; 14; 19.

## PHOSPHORIC ACID (H<sub>3</sub>PO<sub>4</sub>, 98.0)

**CAS/DOT IDENTIFICATION #:** 7664-38-2/UN1805

**SYNONYMS:** orthophosphoric acid, phosphoric acid (aqueous), white phosphoric acid.

**PHYSICAL PROPERTIES:** colorless, syrupy liquid or rhombic crystals; odorless; pleasing acid taste when diluted; viscous liquid can solidify at temperatures below 21°C (70°F); dehydrates to pyrophosphoric acid above 392°F (200°C); easily super-cooled into a glass; will frequently crystallize on prolonged cooling, forming a hemihydrate; becomes anhydrous at 150°C; changes to metaphosphoric acid when heated above 300°C; soluble in alcohol; soluble in ether-alcohol mixture; miscible with water and many organic solvents; very soluble in hot water; MP (42°C, 108°F); BP (213°C, 415°F); DN (1.8741 g/mL at 25°C); LSG (1.87, pure at 77°F); VS (3.86 mPa-s at 20°C); CP (106.1 J/K-mol crystal at 25°C); VD (NA); VP (0.03 mmHg at 20°C).

**CHEMICAL PROPERTIES:** generally unstable; strong acid; can develop a large exotherm on neutralization or dilution; hot concentrated acid attacks porcelain and granite ware; reacts with strong alkalis and most metals; corrosive to ferrous metals and alloys; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-1284.4 kJ/mol crystal at 25°C); H<sub>f</sub> (13.4 kJ/mol at 315.5K).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating Health 3, Flammability 0, Reactivity 0; readily reacts with metals to form flammable hydrogen gas; contact with strong caustics can cause liberation of much heat and violent spattering; very dangerous; forms explosive mixtures with nitromethane; violent reaction with sodium tetrahydroborate; reacts with chlorides and stainless steel to form explosive hydrogen gas; liquid will attack some forms of plastic, rubber, and coatings; heating to decomposition emits toxic fumes of oxides of phosphorus; use water spray or other agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (respiratory damage, irritates eyes, nose and throat); contact (skin and eye burns, dermatitis); ingestion (nausea, vomiting, diarrhea, irritates gastrointestinal tract, loss of consciousness).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink water or milk.

**HUMAN TOXICITY DATA:** oral-man TDLo 1286µL/kg; unreported-man LDLo 220 mg/kg; inhalation-human TCLo 100mg/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory tract; burns on mouth and lips; sour acrid taste; severe gastrointestinal irritation; nausea; vomiting; bloody diarrhea; severe abdominal pains; difficult swallowing; acidemia; thirst; convulsions; collapse; shock; death.

**CHRONIC HEALTH RISKS:** dermatitis; persons with impaired pulmonary function may develop chronic respiratory disease.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1mg/m<sup>3</sup>; ACGIH TLV STEL 3 mg/m<sup>3</sup>; OSHA PEL TWA 1 mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; NIOSH REL STEL 3 mg/m<sup>3</sup>; IDLH 1000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** normal acid protective wear is recommended; wear chemical-resistant gloves; use dust and splash-proof safety goggles; wear self-contained breathing apparatus; showers and eye-wash fountains should be provided in the immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; if in solid form, collect spilled material and place in a secured sanitary landfill; absorb as much as possible in dry earth, sand, or vermiculite.

**DISPOSAL AND STORAGE METHODS:** dilute in cooled quench solution and neutralize with caustic or lime; route to sewage plant; absorb in noncombustible materials such as dry earth, sand or vermiculite and dispose of in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; may be stored in a suitable stainless steel container; separate from alkalis and most metals.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 5000 lbs. (2270 kg); Sf1; Sf3; CW1; CW2; A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used in the manufacture of aluminum products in bright dipping operations; used during the synthesis of detergent and soap builders and water treatment chemicals; used as an acidulant and flavoring agent in manufacture of carbonated beverages, jellies

and preserves; useful as a pharmaceutical aid; use as an acid catalyst in the synthesis of ethylene and in the purification of hydrogen peroxide; also used in dental cements, process engraving, rust-proofing of metals before painting, and in the coagulation of rubber latex.

**KEY REFERENCES:** 3; 4; 5; 6; 8; 9; 10; 11; 12; 16.

### **PHOSPHORUS (yellow) (P<sub>4</sub>, 123.88)**

**CAS/DOT IDENTIFICATION #:** 7723-14-0/UN1381, UN2447

**SYNONYMS:** elemental phosphorus, white phosphorus, yellow phosphorus.

**PHYSICAL PROPERTIES :** colorless, white, or yellowish solid; waxy appearance; darkens on exposure to light; emits a greenish light and gives off white fumes when exposed to air in the dark; produces acrid fumes in air; soluble in oils; moderately soluble in water; soluble in carbon disulfide; MP (44°C, 111°F); BP (280°C, 536°F); DN (1.82 g/cm<sup>3</sup> at 20°C); SG (1.82 at 20°C); CP (23.8 J/K-mol crystal at 25°C); VD (4.42); VP (1 mmHg at 76.6°C); Moh's hardness (0.5).

**CHEMICAL PROPERTIES:** flammable solid; volatile; ignites at about 30°C in moist air; forms tri- or pentahalides on direct combination with the halogens; combines with sulfur to form sulfides; reacts with several metals to form phosphides; treatment with nitric acid yields orthophosphoric acid; reaction with alkali hydroxides leads to the formation of phosphine and sodium hypophosphite; FP (spontaneously flammable in air); LFL/UFL (NA); AT (30°C, 86°F).

**EXPLOSION and FIRE CONCERNS:** flammable solid; NFPA rating Health 4, Flammability 4, Reactivity 2; pyrophoric material; dangerous fire hazard; very reactive; ignites spontaneously in moist air; may explode on contact with oxidizers; combustion in a confined space will remove oxygen and cause asphyxiation; dangerous explosion hazard with alkaline hydroxides, ammonium nitrate, beryllium, iron, lithium, chlorosulfonic acid, performic acid, potassium permanganate, silver nitrate, sodium hydroxide, sulfur trioxide, and many others; incompatible with sulfur, iodine, oil of turpentine, and potassium chlorate; decomposition emits highly toxic fumes of oxides of phosphorus, phosphine, and in presence of water, phosphoric acid; use flooding quantities of water followed by smothering with wet sand, clay or ground limestone for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (severe internal irritation, collapse, convulsions, dilation of pupils, retinal hemorrhage, congestion of blood vessels, photophobia with myosis); contact (severe burns); ingestion (gastrointestinal irritation, bloody diarrhea, liver damage, skin eruption, nausea, vomiting, sweating, cardiomyopathy, cyanosis).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with large amounts of water; provide respiratory support.

**HUMAN TOXICITY DATA:** oral-woman LDLo 22 mg/kg; toxic effect: cardiovascular effects; oral-woman TDLo 11 mg/kg; oral-woman LDLo 4600µg/kg; toxic effect: skin, pulmonary system, gastrointestinal tract; oral-woman TDLo 2600 µg/kg; oral-human LDLo 1400 µg/kg; oral-unspecified LDLo 200 mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes and upper respiratory tract; severe eye and skin burns; severe gastrointestinal irritation; bloody diarrhea; liver damage; skin eruptions; oliguria; circulatory collapse; photophobia with myosis; dilation of pupils; retinal hemorrhage; congestion of blood vessels; coma; convulsions; death.

**CHRONIC HEALTH RISKS:** anemia; weight loss; spontaneous fractures; necrosis of the jaw; brittleness of long bones.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg/m<sup>3</sup>; OSHA PEL TWA 0.1 mg/m<sup>3</sup>; NIOSH REL TWA 0.1 mg/m<sup>3</sup>; IDLH 5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear chemical protective clothing and self-contained breathing apparatus; wear chemical safety goggles or protective face shield; chemical-resistant gloves are recommended.

**SPILL CLEAN-UP:** smother release with wet sand, clay, or ground limestone; shovel into suitable dry container; control runoff and isolate discharged material.

**DISPOSAL AND STORAGE METHODS:** may be disposed in a secured sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers and incompatibles.

**REGULATORY INFORMATION:** T120-a; A1; Reportable Quantity (RQ): 1 lb (0.454 kg); DOT hazard class/division (4.2); labels (spontaneously combustible, poison).

**OTHER COMMENTS:** used in the manufacture of rat poisons; used for smoke screens and gas analysis.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 8; 10; 13; 14; 19.

## **PHOSPHORUS PENTACHLORIDE(PCI<sub>5</sub>, 208.3)**

**CAS/DOT IDENTIFICATION #:** 10026-13-8/UN1806

**SYNONYMS:** pentachlorophosphorus, phosphoric chloride, phosphorus perchloride.

**PHYSICAL PROPERTIES :** white to pale-yellow crystalline solid; pungent, unpleasant odor like hydrochloric acid; fumes in moist air; sublimes at about 100°C without melting; soluble in carbon disulfide and carbon tetrachloride; MP (100°C, 212°F normal pressure sublimes; 148°C, 298°F under pressure decomposes); BP (160°C, 320°F sublimes); DN (4.65 g/L at 296°C); SG (3.60 at 68°F); CP (112.8 J/K-mol gas at 25°C); VD (NA); VP (1 mmHg at 55.5°C); OT (no quantitative data is available).

**CHEMICAL PROPERTIES:** noncombustible solid; heat may contribute to instability; corrosive; water reactive; hydrolyzed by water for form phosphoric acid and hydrogen chloride; reacts with alcohols to form the corresponding chloride; reacts with magnesium oxide, alkalis, and chemically active metals such as sodium and potassium; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-443.5 kJ/mol crystal at 25°C, -374.9 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** not combustible; flammable by chemical reaction; NFPA rating Health 3, Flammability 0, Reactivity 2; contact with water will cause violent spattering and formation of toxic hydrogen chloride gas and phosphoric acid mist; elevated temperatures may cause containers to burst; pressure will develop in closed containers when exposed to moisture; reacts explosively with chlorine dioxide and chlorine, sodium, and urea and heat; ignites on contact with fluorine; forms explosive products with carbamates and 3'-methyl-2-nitrobenzanilide; reacts violently with water, acids, alkalis, alkali metals, alcohols, amines and organic acids; incompatible with aluminum chlorine dioxide, chlorine, diphosphorus trioxide, fluorine, hydroxylamine, magnesium oxide, nitrobenzene, sodium, urea, and water; hazardous

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decomposition product such as hydrogen chloride, carbon monoxide, and phosphoric acid mist may be released in a fire; use carbon dioxide or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (pulmonary edema, irritates eyes, skin and respiratory system); contact (corrosive to body tissues, causes severe eye and skin burns).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink large quantities of water immediately to dilute the phosphorus pentachloride.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes and respiratory system; bronchitis; severe breathing difficulties; irritation of mucous membranes; burning and irritation of skin; pulmonary edema.

**CHRONIC HEALTH RISKS:** dermatitis; target organs: eyes, skin and respiratory.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.85 mg/m<sup>3</sup>; OSHA PEL TWA 1 mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; IDLH 70 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear appropriate protective clothing (boots, gloves, aprons, etc.); use dust- and splash-proof safety goggles; wear self-contained breathing apparatus; facilities for quick drenching of the body and an eye-wash fountain should be provided within immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and disperse vapors; collect spilled material and deposit in sealed containers; cover spill with sodium bicarbonate or an equal mixture of soda ash and slaked lime.

**DISPOSAL AND STORAGE METHODS:** collect spilled material, deposit in sealed containers and dispose of in a secured sanitary landfill; cover with sodium bicarbonate or an equal mixture of soda ash and slaked lime, dilute with water and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; storage should be in tightly closed containers and handled with caution; store under nitrogen; separate from acids, alkalis, alkali metals, and organic acids.

**REGULATORY INFORMATION:** Sfl; A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used as a catalyst in the production of polyethylene from ethylene; used as a chlorinating agent for aryl or alkyl acids and salts, ketones and aldehydes; also used as a dehydrating agent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 16.

### PHOSPHORUS PENTASULFIDE (P<sub>2</sub>S<sub>2</sub> OR P<sub>4</sub>S<sub>10</sub>, 222.3 OR 444.6)

**CAS/DOT IDENTIFICATION #:** 1314-80-3/UN1340

**SYNONYMS:** diphosphorus pentasulfide, phosphoric sulfide, phosphorus persulfide, phosphorus sulfide, suflur phosphide, thiophosphoric anhydride.

**PHYSICAL PROPERTIES :** pale yellow to greenish-yellow crystalline solid; odor of rotten eggs; fumes in moist air; very hygroscopic; soluble in carbon disulfide; soluble in aqueous

solutions of alkali hydroxides; insoluble in cold water; MP (286-290°C, 546.8-554°F); BP (513-515°C, 955.4-959°F); DN (2.09 g/cm<sup>3</sup>); SG (2.09); HV (184 Btu/lb, 102 cal/g, 4.27 x 10<sup>5</sup> J/kg); VD (NA); VP (1 mmHg at 300°C).

**CHEMICAL PROPERTIES:** combustible solid; heat, particularly in presence of moisture contribute to instability; water reactive; reacts with water to form hydrogen sulfide, sulfur dioxide, and phosphoric acid; reacts with alkalies, alcohols, amines, and organic acids; FP (NA); LFL/UFL (NA); AT (142°C, 287°F); HC (-10,890 Btu/lb, -6,050 cal/g, -253.3 x 10<sup>5</sup> J/kg).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 2, Flammability 1, Reactivity 2; may spontaneously ignite in presence of moisture; may be ignited by spark, friction, or static discharge; containers may explode in fire; liberates toxic hydrogen sulfide and phosphorus pentoxide and evolves heat on contact with moisture; dangerous fire hazard in the form of dust; moderate explosion hazard in solid form by spontaneous chemical reaction; can react vigorously with oxidizing materials; reacts with water, steam or acids to produce flammable vapors; incompatible with air, alcohols, and water; combustion by-products include sulfur dioxide, hydrogen sulfide, phosphorus pentoxide, phosphoric acid fume, and carbon monoxide; use dry chemical, carbon dioxide, or sand for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (respiratory paralysis, asphyxia, convulsions, severe breathing difficulties, irritates eyes and respiratory tract, coma); contact (lacrimation, photophobia, vesiculation of the corneal epithelium, acute conjunctivitis, skin irritation); ingestion (irritates gastrointestinal tract).

**HUMAN TOXICITY DATA:** inhalation-human TCLo 100mg/m<sup>3</sup>; inhalation of high concentrations of 1000 to 2000 ppm may cause coma and be rapidly fatal; prolonged exposure to 250 ppm may cause pulmonary edema.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; lacrimation; conjunctival pain; photophobia; kerato-conjunctivitis; corneal vesiculation; dizziness; headache; fatigue; breathing difficulty; coughing; convulsions; rapid olfactory fatigue; coma; death.

**CHRONIC HEALTH RISKS:** headache; tiredness; irritability; insomnia; gastrointestinal disturbances; central nervous system effects; rhinitis; pharyngitis; bronchitis; pneumonitis; cough; apnea.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg/m<sup>3</sup>; ACGIH TLV STEL 3 mg/m<sup>3</sup>; OSHA PEL TWA 1 mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; NIOSH REL STEL 3 mg/m<sup>3</sup>; IDLH 250 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and plastic face shield; use dust-and splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; shovel small quantities into suitable dry container; blanket release with dry sand, clay, or ground limestone; keep water away from release.

**DISPOSAL AND STORAGE METHODS:** shovel small quantities into suitable dry container and burn in a fume hood; dissolve large quantities in a flammable solvent, such as alcohol, and atomize in closed system fitted with adequate scrubber equipment or bury with copious amounts of earth; cover with sodium bicarbonate or an equal mixture of soda ash and slaked lime, dilute with water, and dispose in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; storage should be in tightly closed containers; separate from acids, alkalies, and organic compounds.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 100 lbs (45.4kg); Sfl; CW1; CW2; A1; CAL; DOT hazard class/division (4.3); labels (dangerous when wet).

**OTHER COMMENTS:** used in the preparation of lubrication oil additives; used in the manufacture of safety matches, ignition compounds, and for introducing sulfur into organic compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 16.

### PHOSPHORUS TRICHLORIDE (PCl<sub>3</sub>, 137.32)

**CAS/DOT IDENTIFICATION #:** 7719-12-2/UN1809

**SYNONYMS:** chloride of phosphorus, phosphorus chloride.

**PHYSICAL PROPERTIES :** clear, colorless liquid; sharp, irritating odor like hydrochloric acid; fumes in moist air; soluble in ether, benzene, chloroform, carbon disulfide, and carbon tetrachloride; MP (-112°C, -170°F); BP (76°C, 169°F); DN (1.574 g/mL at 21°C); LSG (1.57 at 21°C); ST (29.1 dynes/cm at 20°C); VS (0.529 mPa-s at 25°C); CP (71.8 J/K-mol gas at 25°C); HV (32.1 kJ/mol at 25°C); VD(4.75); VP(100 mmHg at 21°C, 385 mmHg at 55°C); OT (NA).

**CHEMICAL PROPERTIES:** noncombustible liquid; hydrolyzes in water to form hydrochloric acid and phosphoric acid; highly corrosive; corrodes most common construction materials; reacts with chemically active metals such as sodium, potassium and aluminum; reacts vigorously with strong nitric acid; strong oxidizer; FP (NA); LFL/UFL(NA); AT (NA); HC (NA); HF (-319.7 kJ/mol liquid at 25°C); H<sub>f</sub>(7.1 kJ/mol at 161K).

**EXPLOSION and FIRE CONCERNS:** not flammable; NFPA rating Health 4, Flammability 0, Reactivity 2; strong oxidizer that may ignite combustibles upon contact; reacts explosively with chlorobenzene and sodium, dimethyl sulfoxide, molten sodium, chromyl chloride, nitric acid, sodium peroxide, tetravinyl lead, and oxygen (above 100°C); reacts with carboxylic acids to form violently unstable products; reacts violently or ignites with aluminum, chromium pentafluoride, fluorine, iodine chloride, organic matter, potassium, selenium dioxide, lead dioxide, nitrous acid, and sulfur acids; reacts violently with water and evolves hydrogen chloride and diphosphane gas, that then ignites; will react with water, steam, or acids to produce heat and toxic fumes; hazardous decomposition products include hydrogen chloride, phosphine, diphosphine, phosphoric acid, and carbon monoxide; use water spray, carbon dioxide, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, coughing, wheezing, difficulty breathing); ingestion (burns of the mouth, throat, esophagus, and stomach).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans; oral-unspecified effects LD<sub>50</sub> 350mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; irritation of mucous membranes; severe breathing difficulties; pulmonary edema; mild bronchial spasms; burns of mouth, throat, and stomach; severe skin burns.

**CHRONIC HEALTH RISKS:** pulmonary irritation; nonfibrotic lung disorders; chronic cough; wheezing.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 ppm; ACGIH TLV STEL 0.5 ppm; OSHA PEL TWA 0.5 ppm (3 mg/m<sup>3</sup>); NIOSH REL TWA 0.2ppm (1.5 mg/m<sup>3</sup>); NIOSH REL STEL 0.5 ppm (3 mg/m<sup>3</sup>); IDLH 25 ppm.

**PERSONAL PROTECTION:** wear rubber overclothing (including gloves) wherever hydrochloric acid may be concentrated; use splash-proof safety goggles and self-contained breathing apparatus; facilities for quick drenching of the body and eye wash fountains should be provided in the immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth, sand, or vermiculite; cover with sodium bicarbonate or an equal mixture of soda ash and slaked lime, and dilute with water.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand, or vermiculite and dispose of in a secured sanitary landfill; cover with sodium bicarbonate or an equal mixture of soda ash and slake lime, dilute with water, and place in a sanitary landfill; store in a cool, dry location with adequate ventilation; keep in tightly closed containers; separate from acids, alkalis, organics, and alkali metals.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 1000 lbs. (454 kg); Sf1; Sf2; CW1; CW2; A1; A5; CAL; DOT hazard class/division (8); labels (corrosive, poison).

**OTHER COMMENTS:** used during deposition of metallic coatings; used during synthesis of plasticizers and intermediates; used in the preparation of dyes, pharmaceuticals, other chlorinating agents, and other organic chemicals; used in the treatment of polypropylene before drying in manufacture of knitted fabrics.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 11; 12; 16.

## **PHTHALIC ANHYDRIDE (C<sub>6</sub>H<sub>4</sub>(CO)<sub>2</sub>O, 148.12)**

**CAS/DOT IDENTIFICATION #:** 85-44-9/UN2214

**SYNONYMS:** 1,2-benzenedicarboxylic acid anhydride, 1,3-dioxophthalan, 1,3-isobenzofurandione, 1,3-phthalandione, phthalic acid anhydride.

**PHYSICAL PROPERTIES :** white, lustrous needles; mild characteristic choking odor; soluble in alcohol and hot benzene; sparingly soluble in ether; very slightly soluble in water; solid sinks in water; MP (131°C, 268°F); BP (285°C, 544°F); DN (1.527 g/cm<sup>3</sup> at 20°C); SG (1.53); ST (35.5 dynes/cm at 155°C); CP (160.0 J/K-mol crystal at 25°C); HV (13,919.0 gcal/gmole); VD (5.10); VP (1 mmHg at 96.5°C, 40 mmHg at 172°C, 100mmHg at 202°C, 760mmHg at 284.5°C); OT(0.053 µl/L).

**CHEMICAL PROPERTIES:** combustible solid; corrosive; very slow reaction with water; converted to phthalic acid in hot water; reacts with strong oxidizers; FP (152°C, 305°F); LFL/UFL(1.7%, 10.4%); AT (570°C, 1058°F); HC (783.4 kcal); HF (-460.1 kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 3, Flammability 1, Reactivity 0; moderate explosion hazard in the form of dust when subjected to

flame; dust can also form explosive mixtures with air; production of material is responsible for many industrial explosions; reacts violently with nitric acid and sulfuric acid above 80°C; can react vigorously with oxidizing materials; mixtures with sodium nitrite or copper oxide explode when heated; can ignite by electric sparks; may generate electrostatic charges; use dry chemical, foam, carbon dioxide, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, increased mucous secretion, sore throat, breathing difficulty, upper respiratory tract irritation); skin contact (acid burns, dermatitis, sensitization, severe thermal burns caused by liquid); ingestion (sore throat, vomiting, diarrhea, cramps, abdominal pain).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** no data available in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory system; nasal ulcer bleeding; sneezing; acute nose pain; coughing; bronchitis; conjunctivitis; abdominal pain; diarrhea; vomiting.

**CHRONIC HEALTH RISKS:** destructive to tissues of mucous membranes; irritation of skin; bloody sputum; emphysema; bronchial asthma; lowering of blood pressure; central nervous system excitation; dermatitis; skin sensitization.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1ppm; OSHA PEL TWA 2ppm (12 mg/m<sup>3</sup>); NIOSH REL TWA 1ppm (6mg/m<sup>3</sup>); IDLH 60mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear coveralls or rubber apron, rubber shoes or boots; gauntlet-type leather or rubber gloves are recommended; wear chemical safety goggles or face shield; self-contained breathing apparatus is recommended in high vapor concentrations.

**SPILL CLEAN-UP:** shovel small quantities into suitable dry container, and burn in a fume hood; dissolve large quantities in a flammable solvent, and atomize in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; absorb liquid containing phthalic anhydride in noncombustible materials such as dry earth or sand.

**DISPOSAL AND STORAGE METHODS:** can dilute, neutralize, or precipitate out phthalate salts for recovery; dissolve in flammable solvent, such as alcohol, and atomize in suitable combustion chamber equipped with afterburner and scrubber; liquid may be absorbed in dry earth, sand, or vermiculite, and placed in a sanitary landfill; store in a cool, dry location; separate from acids, strong oxidizers, alkalies, reducing agents, and moisture.

**REGULATORY INFORMATION** CA2; R4; R6; U waste # (U190); Reportable Quantity (RQ): 5000 lbs (2270kg); Sf1; Sf3; A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used in the manufacture of phthaleins, phthalates, benzoic acid, synthetic indigo, and artificial resins; used as a chemical intermediate for dioctyl phthalates, phthalate plasticizers, and many phthalate esters; used as a hardener for resins and polyesters; employed in the synthesis of phenolphthalein, chlorinated products, diethyl phthalate, dimethyl phthalate, and pharmaceutical intermediates.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

**PICLORAM (C<sub>6</sub>H<sub>3</sub>Cl<sub>3</sub>O<sub>2</sub>N<sub>2</sub>, 241.46)****CAS/DOT IDENTIFICATION #:** 1918-02-1/none**SYNONYMS:** 4-amino-3,5,6-trichloropicolinic acid, 4-amino-3,5,6-trichloro-2-picolinic acid, 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid, atcp, grazon<sup>®</sup>, tordon<sup>®</sup>.**PHYSICAL PROPERTIES :** colorless crystals or white powder; chlorine-like odor; very sparingly soluble in water; sparingly soluble in organic solvents, including acetone, 2-propanol, and dichloromethane; MP (218-219°C, 424-426°F); BP (decomposes); DN (unknown); SG (unknown); VD (NA); VP (6.16 x 10<sup>-7</sup> mmHg at 95°F).**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; reacts with strong bases; attacks mild steel; FP (unknown); LFL/UFL (unknown); AT (NA).**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating (NA); hydrolyzes on contact with hot concentrated alkali; liquid formulations containing organic solvents may be flammable; decomposes on heating producing nitrogen oxides of hydrogen chloride; use water spray, foam, or powder for firefighting purposes.**HEALTH SYMPTOMS:** inhalation (cough, burning sensation, irritates eyes, skin and respiratory system); eye/skin contact (redness, pain); ingestion (cough, nausea, burning sensation, effects on the liver).**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air; if not breathing provide respiratory support or oxygen as indicated; get immediate medical attention.**HUMAN TOXICITY DATA:** no toxicity data reported in humans.**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; cough; burning sensation; nausea.**CHRONIC HEALTH RISKS:** may have effects on the liver; targets eyes, skin, respiratory system, liver, and kidneys.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA (no established REL); IDLH (not determined).**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use dust-proof safety goggles in combination with breathing protection; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use positive pressure self-contained breathing apparatus; for extra personal protection, a P3 filter respirator for toxic particles may be employed; maintain eyewash fountains and quick-drench facilities in work area.**SPILL CLEAN-UP:** sweep spilled substance into covered containers; moisten first to prevent dusting; carefully collect remainder, then remove to a safe place; do not wash away into sewer.**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an appropriate waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; separate from strong alkalis, food and feedstuffs.

**REGULATORY INFORMATION:** S1; S24; S32; S50; S61; S62; F1; F2; F7; F8; Sf3; A1; CAL.

**OTHER COMMENTS:** used as an herbicide and defoliant; use has since been restricted; insufficient data is available on the effect of this substance on human health; however, extreme care must be taken to avoid release to the environment since this substance is toxic to soil and water organisms.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### **PICRIC ACID (HOC<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>3</sub>, 229.12)**

**CAS/DOT IDENTIFICATION #:** 88-89-1/UN0154, UN1344

**SYNONYMS:** carbazotic acid, 2-hydroxy-1,3,5-trinitrobenzene, melinite, nitroxanthic acid, phenol trinitrate, picronitric acid, 2,4,6-trinitrophenol.

**PHYSICAL PROPERTIES :** pale yellow crystals; odorless; very bitter taste; soluble in alcohol, chloroform, benzene, and ether; moderately soluble in water; MP (122°C, 252°F); BP (> 300°C, 572°F explodes); DN (1.763 g/cm<sup>3</sup>); SG (1.76); VD (7.90); VP (<1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible solid; highly unstable in crystalline form; can react vigorously with oxidizing materials and reducing materials ; readily forms salts, known as picrates; strong sensitizer; anhydrous material is shock-, friction-, and heat-sensitive; air or oxygen not required for oxidation or decomposition; FP (150°C, 302°F); LFL/UFL(NA); AT (300°C, 572°F).

**EXPLOSION and FIRE CONCERNS:** flammable solid; NFPA rating Health 3, Flammability 4, Reactivity 4; very unstable; severe explosion hazard when shocked or exposed to heat; can form salts of picric acid that are initiators and shock-sensitive; forms unstable salts with concrete, ammonia, bases, and metals (e.g., lead, mercury, copper, and zinc); can form extremely explosive mixtures with uranium perchlorate; mixtures with aluminum and water ignite after a delay period; incompatible with all oxidizable substances, albumin, gelatin, and alkaloids; toxic gases and vapors, such as carbon monoxide and oxides of nitrogen, may be released in a fire; use flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (unconsciousness, weakness, muscle pain, kidney problems, myalgia, anuria, polyuria, temporary coma); ingestion (bitter taste, headache, nausea, vomiting, diarrhea, dizziness, yellow coloration of the skin, anuria, hepatitis, hematuria, albuminuria); contact (sensitization dermatitis on the face, formation of papules and vesicles, staining of skin and hair).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; nausea; vomiting; diarrhea; headache; dizziness; abdominal pain; corneal injury; weakness; stupor; convulsions; loss of consciousness; bitter taste; death.

**CHRONIC HEALTH RISKS:** destruction of red blood cells; destruction of erythrocytes; hemorrhagic nephritis; hepatitis; yellow staining of skin and hair; yellow tinted vision; blood in urine; sensitization dermatitis; hematuria; albuminuria; allergic reactions.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1mg/m<sup>3</sup>; OSHA PEL TWA 0.1 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.1 mg/m<sup>3</sup>; NIOSH REL STEL 0.3 mg/m<sup>3</sup>(skin); IDLH 75 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, including chemical-resistant gloves; use dust- and splash-proof safety goggles; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill; cautiously shovel into suitable dry container; prompt cleanup and removal are necessary; avoid shock, friction, or heat during cleanup.

**DISPOSAL AND STORAGE METHODS:** may be disposed of only by explosive experts; store in a cool place, remote from fire; separate from organic materials, transition and heavy metals; do not allow material to become dry.

**REGULATORY INFORMATION:** Sf3; A1; CAL; DOT hazard class/division (4.1); labels (flammable solid).

**OTHER COMMENTS:** used in the manufacture of pyrotechnics and as an oxidizer in matches; used in the manufacture of colored glass and electric batteries; used in the synthesis of dyes and dye intermediates; use in manufacture of medicinals; useful as a chemical reagent in identification, isolation, and purification of other compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 16.

### **PINDONE (C<sub>14</sub>H<sub>14</sub>O<sub>3</sub>, 230.28)**

**CAS/DOT IDENTIFICATION #:** 83-26-1/none

**SYNONYMS:** tert-butyl valone, 1,3-dioxo-2-pivaloyl-lindane, pival<sup>®</sup>, pivalyl, 2-pivalyl-1,3-indandione.

**PHYSICAL PROPERTIES:** bright yellow powder or crystals; practically odorless; soluble in most organic solvents; insoluble in water; MP (108-110°C, 226.4 - 230°F); BP (decomposes); DN/SG (1.06); VD (data not available); VP (very low).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; very high temperatures will contribute to instability; no known incompatibilities; no hazardous decomposition products have been reported; FP (data not available); LFL/UFL (data not available); AT (data not available).

**EXPLOSION and FIRE CONCERNS:** nonflammable solid; NFPA rating (not rated); not expected to be a fire hazard; not expected to be an explosion hazard; no incompatibilities and/or hazardous reactions have been reported; heating to decomposition emits irritating smoke and fumes; in case of fire in the surroundings, use carbon dioxide, dry chemical, appropriate foam or water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (bleeding from nose or gums, back pain, pallor, weakness, reduced clotting of blood, smoky urine, black tarry stools, abdominal pain).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** epistaxis (nosebleed); bleeding from gums, and from minor cuts and bruises; pallor; weakness; smoky urine; black, tarry stools; stomach and back pain may occur one to several days after exposure.

**CHRONIC HEALTH RISKS:** repeated exposure may cause generalized bleeding, such as nosebleeds; may cause excessive bleeding from minor cuts and bruises; causes reduced blood clotting, which leads to hemorrhaging; may cause smoky urine, black tarry stools, abdominal and back pain.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg/m<sup>3</sup>; OSHA PEL TWA 0.1 mg/m<sup>3</sup>; NIOSH REL TWA 0.1 mg/m<sup>3</sup>; IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron, or coveralls; wear chemical safety goggles; enclose operations and/or use local exhaust ventilation at the site of release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear a self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eye-wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; carefully sweep up, place in an appropriate container, and burn in a safe place (such as a fume hood).

**DISPOSAL AND STORAGE METHODS:** bury or burn with trash in accordance with local, state, and federal regulations; dispose of empty bag/box in sanitary landfill or by incineration/burning; may also be disposed of by dissolving in a flammable solvent (such as alcohol) and atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; store in a cool, dry area; use only with adequate ventilation; keep away from products with strong odors; keep away from children and pets.

**REGULATORY INFORMATION:** CAL; DOT hazard class/division (none); label (none required).

**OTHER COMMENTS:** used as an anticoagulant and rodenticide; blinded with other materials (cereal, bait, liquid, etc.), in pesticide formulations; has also been used as an intermediate in pharmaceutical synthesis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 16.

## **PLASTER OF PARIS (CaSO<sub>4</sub>·0.5H<sub>2</sub>O, 145.2)**

**CAS/DOT IDENTIFICATION #:** 26499-65-0/none

**SYNONYMS:** calcium sulfate, hemihydrate, dried calcium sulfate, gypsum hemihydrate, hemihydrate gypsum. (note: plaster of paris is the hemihydrate form of calcium sulfate and gypsum is the dihydrate form).

**PHYSICAL PROPERTIES :** white or yellowish, finely divided powder; odorless; tasteless; hygroscopic (i.e., absorbs moisture from the air); loses water when heated above

163°C (325°F); slightly soluble in hot water; soluble in glycerin, ammonium salts, and acids; MP (163°C, 325°F); BP (NA); DN (2.5 g/mL at 25°C and 750 mmHg); SG (2.5); VD (NA); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** noncombustible solid; can react with water to form gypsum; can react vigorously with aluminum powder and phosphorus; incompatible with moisture and water; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** nonflammable; NFPA rating (NA); reacts violently or explosively upon heating when mixed with aluminum powder; will ignite at high temperatures when mixed with phosphorus; mixtures with diazomethane vapor can result in an explosive exothermic reaction; when primed at a high temperature with a potassium nitrate-calcium silicide mixture, mixtures with excess red phosphorus will burn; containers may explode when heated; toxic fumes of oxides of sulfur are emitted when heated to decomposition; use water spray, dry chemical, carbon dioxide, fog, or regular foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, bronchitis, pneumonitis, bronchospasm, wheezing); contact (dermal irritation or burns, dermal hypersensitivity, eye irritation, pain, swelling, lacrimation (discharge of tears), photophobia (abnormal visual intolerance to light)); ingestion (obstruction of intestines).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if ingested, dilute immediately with 4 to 8 ounces of water; drinking glycerin, gelatin solutions, or large volumes of water may delay hardening.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans; for the dihydrate: inhalation-human TCLo 194 g/m<sup>3</sup>/10Y-I; toxic effect: nose, pulmonary effects.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and mucous membranes; conjunctivitis; rhinitis; coughing; sneezing; labored breathing; epistaxis (nosebleed); pneumonia; intestinal obstruction.

**CHRONIC HEALTH RISKS:** bronchospasm; wheezing; chronic bronchitis; lacrimation; photophobia (abnormal visual intolerance to light); dermal hypersensitivity.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>; NIOSH REL TWA 5 mg(respirable fraction)/m<sup>3</sup>; IDLH (NA).

**PERSONAL PROTECTION:** wear chemical protective clothing which is loose-fitting and made of dust-tight materials; dust-proof safety goggles and a dust mask should be worn; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** isolate spill or leak area immediately; wear protective clothing and equipment when cleaning up a spill; vacuum spill or use other methods which avoid raising dust; take up with sand or other noncombustible absorbent material and place into containers for later disposal; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** land-filling is the suggested disposal method; prevent entry into waterways, sewers, basements or confined areas; store in a cool, dry location with adequate ventilation; storage should be in tightly sealed containers; keep separate from diazomethane vapor, aluminum powder, and phosphorus.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used for creating casts and moldings; used in tiles, stucco, wall plaster, and wallboard; present in dental casting materials; can be formed by heating gypsum.

**KEY REFERENCES:** 4; 15.

**PLATINUM, METAL AND SOLUBLE SALTS** (Soluble platinum salts have variable molecular formulas. The molecular formula for platinum is Pt. Soluble platinum salts have variable formula weights. The formula weight for platinum is 195.09).

**CAS/DOT IDENTIFICATION #:** Soluble platinum salts have variable CAS #'s. The CAS # for platinum is 7440-06-4. There is no DOT identification number listed for platinum in the literature.

**SYNONYMS:** synonyms vary depending upon the specific soluble platinum salt. The synonyms for platinum metal are as follows: platinum black, platinum metal, platinum sponge.

**PHYSICAL PROPERTIES :** Appearance and odor vary depending upon the specific soluble platinum salt. Physical properties of platinum metal and two specific compounds are provided for illustrative purposes. (platinum) silvery-white metals; malleable, lustrous, and ductile; face-centered cubic structure; "platinum black" is a velvety-black, finely divided powder; "platinum sponge" appears as spongy masses; insoluble in mineral and organic acids; soluble in aqua regia and fused alkalis; not soluble in water; MP (1772°C, 3222°F); BP (3827°C, 6921°F); DN (21.447 g/cm<sup>3</sup> at 20°C); SG (21.45); CP (0.0314 cal/g at 0°C); VD (NA); CP (approximately 0 mmHg at 20°C); BHN (55). (platinum tetrachloride) reddish-brown crystals; hygroscopic; soluble in water, alcohol, and acetone; MP (decomposes at 370°C, 698°F); BP (NA); DN (4.30 g/cm<sup>3</sup> at 25°C); SG (4.30); VD (NA); VP (approximately 0 mmHg at 20°C). (ammonia chloroplatinate) orange-red crystals or yellow powder; slightly soluble in water; insoluble in alcohol; MP (decomposes); BP (NA); DN (3.06 g/cm<sup>3</sup>); SG (3.06); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** Properties vary depending upon the specific soluble platinum salt. Chemical properties of platinum metal and two specific compounds are provided for illustrative purpose. (platinum) stable under ordinary conditions of use and storage; does not corrode or tarnish on exposure to air; heated platinum absorbs large volumes of hydrogen and retains it at ordinary temperatures; unaffected by air, water, or single mineral acids; absorbs carbon dioxide, carbon monoxide, and nitrogen; a strong complexing agent; forms chloroplatinic acid on reaction with boiling aqua regia; reacts with molten alkali cyanides; abnormally sensitive to poisons; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); H<sub>f</sub> (22.17 kJ/mol at 2041.5K). (platinum tetrachloride and ammonium chloroplatinate) high temperatures may cause formation of poisonous chlorine gas; decomposes at melting point.

**EXPLOSION and FIRE CONCERNS:** Platinum metal is a noncombustible solid in bulk form; finely divided powder is a powerful catalyst and can be dangerous to handle; used catalysts may be explosive; attacked by halogens and by fusion with caustic alkalis; may undergo hazardous reaction with arsenates and phosphates in presence of reducing agents; incompatible with aluminum, acetone, ethanol, selenium, tellurium, vanadium dichloride + water, hydrazine, hydrogen peroxide, lithium, ozonides, methyl hydroperoxide, nitrosyl chloride, peroxymonosulfuric acid, and various fluorides; platinum amine nitrates and perchlorate either detonate when heated or are impact-sensitive; in case of fire in the surroundings, use agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (wheezing, coughing, running of the nose, shortness of breath, chest tightness, bluish discoloration of skin); contact (skin sensitization, itchy red rash); ingestion (symptoms parallel those of inhalation).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush skin immediately with large amounts of soap and water; if breathing is difficult, provide oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, give large quantities of water and induce vomiting; get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** exposure to dust of soluble platinum salts may cause irritation to eyes, nose, and throat; may cause rhinorrhea, sneezing, tightness of chest, dyspnea, cyanosis, wheezing, and coughing.

**CHRONIC HEALTH RISKS:** repeated exposure to soluble platinum salts may cause symptoms of platinum allergy, including rhinitis, conjunctivitis, asthma, urticaria, and contact dermatitis; may cause lymphocytosis, tetrachloroplatinates are reported to be mutagens.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg (metal)/m<sup>3</sup>, 0.002 mg (soluble salts as Pt)/m<sup>3</sup>; OSHA PEL TWA 1 mg (metal)/m<sup>3</sup>, 0.002 mg (soluble salts as Pt)/m<sup>3</sup>; NIOSH REL TWA 1 mg (metal)/m<sup>3</sup>, 0.002 mg (soluble salts as Pt)/m<sup>3</sup>; IDLH (metal) not determined, 4 mg (soluble salts as Pt)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear clean-body clothing and chemical resistant gloves; use dust and splash-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; cautiously collect spilled material for disposal in a secured, sanitary landfill; absorb liquids containing soluble platinum salts in dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** platinum and soluble platinum salts may be disposed of in sealed containers in a secured, sanitary landfill; store in a cool, dry location, maintain adequate ventilation; keep in tightly closed containers, protected from light; separate from incompatibles such as aluminum, phosphorus, lithium, tellurium, selenium, arsenic, and various fluorides.

**REGULATORY INFORMATION:** A1; DOT classification (none).

**OTHER COMMENTS:** Platinum metal is used in the manufacture of apparatus used in laboratories and industries, including thermocouples, acid-proof containers, chemical reaction vessels, platinum resistance thermometers, electrodes, etc.; has found applications in dentistry, electroplating industry, and in the jewelry industry; soluble platinum salts have been used as catalysts in the production of high octane gasoline, vinyl esters, petrochemicals, and pharmaceuticals; platinum metals, as well as soluble platinum salts, have been employed as oxidation catalysts in the manufacture of sulfuric acid, nitric acid from ammonia, and acetic acid; soluble platinum salts have been used and reused in the reclamation of platinum ore.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 16.

**PORTLAND CEMENT** (typically mixture of  $2\text{CaO}\cdot\text{SiO}_2$ ,  $3\text{CaO}\cdot\text{Al}_2\text{O}_3$ ,  $3\text{CaO}\cdot\text{SiO}_2$ ,  $4\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot\text{Fe}_2\text{O}_3$ ; variable molecular weight)

**CAS/DOT IDENTIFICATION #:** 65997-15-1/NA

**SYNONYMS:** cement, hydraulic cement, portland cement silicate.

**PHYSICAL PROPERTIES :** finely divided gray powder containing less than 1% crystalline silica; odorless; insoluble in water; mixture with water, sand, and stones is fluid or plastic-like; MP (NA); BP (NA); SG (much greater than 1); VD (NA); VP (0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** very stable; no conditions contributing to instability; forms a sufficiently alkaline mixture with water, sand, and stones; no incompatibilities or reactivities reported; no hazardous decomposition products; no special precautions; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (NA); no incompatibilities reported; no hazardous decomposition products; no special precautions recommended.

**HEALTH SYMPTOMS:** inhalation (wheezing, shortness of breath, irritates eyes, nose and skin); ingestion (expectoration, coughing with sputum and phlegm, chest x-ray changes, bronchitis); contact (mild dermatitis, erythema and mild scaling of skin, allergic skin rashes).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** no data has been reported for Portland cement in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and nose; smarting and burning sensation in the eye; corneal edema; superficial injuries of the conjunctiva; immediate visual impairment resulting in seeing colored rings of haloes about lights.

**CHRONIC HEALTH RISKS:** chronic eye irritation; nose ulcers; allergic skin rashes; increased wheezing; shortness of breath; cough with sputum; cough with phlegm; increased incidence of bronchitis; chronic conjunctivitis; expectoration; exertional dyspnea; x-ray changes of the lungs; respiratory impairment; impaired pulmonary function; dermatitis of hands, forearms, and feet; eczematous lesions with vesicles, erythema and fissures.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10mg(total dust)/m<sup>3</sup>; NIOSH REL TWA 5 mg(respirable fraction)/m<sup>3</sup>; IDLH 5000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and eight-inch minimum face shields; use dust-and splash-proof safety goggles where powdered Portland cement or liquids containing Portland cement may contact the eyes; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill; keep water away from release; containerize all spilled material in a clean dry container using only clean dedicated equipment for cleanup; isolate discharged material for proper disposal.

**DISPOSAL AND STORAGE METHODS:** collect spilled material in a convenient and safe manner and dispose of in a secured sanitary landfill; store in a cool, dry location with adequate ventilation.

**REGULATORY INFORMATION:** A1; A3.

**OTHER COMMENTS:** used in the manufacture of mortars for building blocks, bricks, stone and pre-cast items; also used as a moisture sealant for exterior of concrete blocks; used in concrete on highway paving, domestic and commercial building construction, and in pre-cast concrete articles; useful in light-weight concrete, terrazzo, stucco, asbestos cement products, interior surfaces, and exterior surfaces.

**KEY REFERENCES:** 4; 5; 6; 7; 16.

**PROPANE (CH<sub>3</sub>CH<sub>2</sub>CH<sub>3</sub>, 44.10)**

**CAS/DOT IDENTIFICATION #:** 74-98-6/UN1978

**SYNONYMS:** bottled gas, dimethylmethane, n-propane, propyl hydride.

**PHYSICAL PROPERTIES :** colorless gas; odorless when pure; foul-smelling odorant is added when used for fuel purposes; heavier than air; shipped as a liquefied compressed gas; soluble in ether and alcohol; slightly soluble in water; FZP (-189.9°C, -309.8°F); BP (-42.5°C, -44.5°F); DN (0.531 g/mL liquid at 0°C); LSG (0.53); VS (8.2 μPa-s gas at 25°C); HV (14.79 kJ/mol at 25°C); VD (1.56); VP (8.4 atm, 6,384 mmHg at 70°F).

**CHEMICAL PROPERTIES:** flammable gas; burns with a luminous, smoky flame; can react vigorously with oxidizers; FP (-105°C, -157°F); LFL/UFL (2.3%, 9.5%); AT (450°C, 842°F); HC (528.4 cal constant volume, 553.5 cal constant pressure); HF (-104.7 kJ/mol gas at 25°C); T<sub>c</sub> (96.81°C, 206.26°F); P<sub>c</sub> (42.01 atm, 31,927.6 mmHg).

**EXPLOSION and FIRE CONCERNS:** flammable; dangerous fire risk when exposed to heat or flame; NFPA rating Health 1, Flammability 4, Reactivity 0; explosive in vapor form when exposed to heat or flame; reacts explosively with chlorine dioxide; violent exothermic reaction with barium peroxide and heat; incompatible with strong oxidizers; heating to decomposition emits irritating fumes; stop flow of gas or use agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, narcosis, excitation, asphyxiation); contact (liquid can have refrigerating effect or cause burns to the skin).

**FIRST AID:** flush eyes immediately with plenty of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no toxicity data available for propane.

**ACUTE HEALTH RISKS:** dizziness; disorientation; excitation; asphyxiation; liquid may cause frostbite.

**CHRONIC HEALTH RISKS:** central nervous system effects.

**EXPOSURE GUIDELINES:** ACGIH TLV asphyxiant; OSHA PEL TWA 1000 ppm (1800 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (1800mg/m<sup>3</sup>); IDLH 2100 ppm.

**PERSONAL PROTECTION:** wear gastight suit; rubber gloves and large, heavy face shields are also recommended; use splash-proof safety goggles where liquid propane may contact the eyes; wear self-contained breathing apparatus; facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

**SPILL CLEAN-UP:** leaking containers should be removed to an isolated, well-ventilated area; apply universal gelling agent to immobilize spill or use fly ash or cement powder to absorb the liquid; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be subjected to ultimate disposal by controlled incineration; may be stored in liquefied form under its vapor pressure at normal atmospheric temperatures both above and below ground; refrigerated liquid storage at atmospheric pressure may be used; systems are closed and insulated, and the liquid petroleum gas vapor serves as the refrigerant for the system as it is circulated through pumps and compressors; may also be stored in pits in the earth capped by metal domes, and in underground chambers.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (2.1); labels (flammable gas).

**OTHER COMMENTS:** used in organic synthesis and as a refrigerant; used as a household and industrial fuel gas, sometimes mixed with butane; also used in the manufacture of ethylene; useful as an extractant, solvent, refrigerant, gas enricher, aerosol propellant, and mixture for bubble chambers.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9.

### **beta-PROPIOLACTONE (C<sub>3</sub>H<sub>4</sub>O<sub>2</sub>, 72.06).**

**CAS/DOT IDENTIFICATION #:** 57-57-8/UN2810

**SYNONYMS:** bpl, hydracrylic acid  $\beta$ -lactone, 3-hydroxy- $\beta$ -lactone, 3-hydroxypropionic acid lactone, 2-oxetanone, propanolide, 1,3-propiolactone, 3-propiolactone.

**PHYSICAL PROPERTIES:** colorless liquid; pungent, slightly sweet odor; soluble in water; miscible with ether, ethanol, chloroform, and acetone at 25°C; MP(-33.4°C, -28°F); BP(162°C, 323.6°F at 760 mmHg); DN(1.1490 g/mL at 20°C); LSG(1.15); HV(47.03 kJ/mol at 25°C); VP(3.4 mmHg at 25°C).

**CHEMICAL PROPERTIES:** stable when stored in glass containers at 5°C (41°F); can undergo hydrolysis to hydracrylic acid; reacts with alcohol; incompatible with acetates, halogens, thiocyanates, and thiosulfates; FP(74°C, 165°F); LFL/UFL (2.9%, unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 1, Flammability 2, Reactivity 0; explosive vapor/air mixtures may be formed above 74°C; substance may polymerize upon storage or due to warming with fire or explosion hazard; decomposes at 323°F; hazardous decomposition products include carbon monoxide and carbon dioxide; use powder, alcohol-resistant foam, water spray or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, headache, shortness of breath, burning sensation, nausea, vomiting, irritates eyes, skin, and respiratory system); skin contact (burns of the skin, blisters); eye contact (severe deep burns, redness, pain) ingestion (burning sensation, sore throat, nausea, vomiting).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, give oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, rinse mouth and seek medical attention.

**HUMAN TOXICITY DATA:** otr-human fibroblast 28 $\mu$ mol/L.

**ACUTE HEALTH RISKS:** severe irritation of eyes, nose and throat; irritation of respiratory tract; irritation of skin; cough, headache, shortness of breath; burning sensation of mouth and stomach; sore throat; skin burns; blistering of skin, corneal opacity; frequent urination; hematuria (blood in urine); muscular spasms; liver and kidney tubular damage; convulsions; nausea; vomiting; death.

**CHRONIC HEALTH RISKS:** substance is probably carcinogenic to humans; human mutation data has been reported; EPA Group B2: probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV 0.5 ppm (1.5 mg/m<sup>3</sup>) suspected human carcinogen; OSHA PEL (1910.1013) carcinogen; NIOSH REL potential occupational carcinogen; IDLH (not determined) potential occupational carcinogen.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear splash-proof safety goggles or face shield; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; collect spilled liquid in sealable containers or absorb in sand or inert absorbent; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured sanitary landfill; store in tightly closed containers in a cool, dry location; maintain adequate ventilation along the floor; separate from food and feedstuffs.

**REGULATORY INFORMATION:** CA2; Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf2; Sf3; A1; A4; CAL; DOT hazard class/division (6.1); labels (do not transport with feed and foodstuffs.).

**OTHER COMMENTS:** used as a chemical intermediate in organic synthesis; used as a sterilant for blood plasma, water, milk, nutrient broth, applications in the medical field, including vaccines, surgical instruments, tissue grafts, and enzymes; has been used against viruses, such as vegetative bacteria and pathologic fungi.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14; 19.

### **n-PROPYL ACETATE (CH<sub>3</sub>COOCH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>, 102.15)**

**CAS/DOT IDENTIFICATION #:** 109-60-4/UN1276

**SYNONYMS:** 1-acetoxyp propane, ethanoic acid propyl ester, propyl acetate, n-propyl ester of acetic acid, propyl ethanoate.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mild, fruity odor; pleasant, bitter-sweet flavor reminiscent of pears; miscible with alcohol, ether, ketones, esters, and hydrocarbons; also miscible with castor and linseed oils; soluble in water; MP (-92.5°C, -134.5°F); BP (101.6°C, 215°F); DN (0.836 g/mL at 20°C); LSG (0.84); ST (24.3 dynes/cm at 20°C); VS (0.544 mPa-s at 25°C); HV (145 Btu/lb, 80.3 cal/g, 3.36 x 10<sup>5</sup> J/kg); VD (3.52); VP (40 mmHg at 28.8°C); OT (0.21 mg/m<sup>3</sup> low, 105 mg/m<sup>3</sup> high).

**CHEMICAL PROPERTIES:** flammable liquid; can react vigorously with oxidizing materials; also reactive with nitrates, alkalis, and acids; FP (14.4°C, 58°F); LFL/UFL (1.7%, 8.0%); AT (450°C, 842°F).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; dangerous fire hazard when subjected to heat, flame or oxidizers; explosive in vapor form; vapor may explode if ignited in confined area; flashback along vapor trail may occur; reacts vigorously with oxidizing materials; incompatible with nitrates, strong oxidizers, alkalis, and acid; decomposition emits acrid smoke and irritating fumes; use carbon dioxide, foam, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (lacrimation, coughing, nausea, vomiting, dizziness, narcotic effects, irritates eyes, nose and throat); contact (irritates skin, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 1000mg/m<sup>3</sup>; toxic effect: eye, pulmonary system.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; nausea; vomiting; dizziness; loss of consciousness; difficulty in breathing; lacrimation; coughing; slight stupefaction.

**CHRONIC HEALTH RISKS:** severe irritation; narcosis; death in some cases; dermatitis; central nervous system depression; fatigue; sleepiness; retarded respiration.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm; ACGIH TLV STEL 250 ppm; OSHA PEL TWA 200 ppm (840 mg/m<sup>3</sup>); OSHA PEL STEL 250 ppm; NIOSH REL TWA 200 ppm (840 mg/m<sup>3</sup>); NIOSH REL STEL 250 ppm (1050 mg/m<sup>3</sup>); IDLH 1700 ppm.

**PERSONAL PROTECTION:** wear self-contained breathing apparatus; wear boots, gloves, sleeves, aprons, etc.; wear splash-proof safety goggles.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in fume hood; dissolve in flammable solvent and atomize large amounts in suitable combustion chamber; absorb as much as possible in noncombustible materials; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in noncombustible materials such as dry earth, sand, or vermiculite, and place in a secured sanitary landfill; dissolve in additional flammable solvent and atomize in suitable combustion chamber equipped with effluent gas cleaning device; store in a cool, dry, well-ventilated location; isolate from oxidizing material.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** powerful solvent, used in nitrocellulose lacquers, waxes, plastics, and natural and synthetic resins; used as a chemical intermediate for flavors, perfumes, and organic syntheses; useful as a lab reagent.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 11; 13; 14.

**n-PROPYL ALCOHOL (CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>OH, 60.11)**

**CAS/DOT IDENTIFICATION #: 71-23-8/UN1274**

**SYNONYMS:** ethyl carbinol, 1-hydroxypropane, 1-propanol, n-propanol, propyl alcohol.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mild alcohol-like and slightly stupefying odor; miscible with water, alcohol and ether; MP (-127°C, -197°F); BP (97°C, 207°F); DN (0.8053 g/mL at 20°C); LSG (0.81); ST (23.32 mN/m at 25°C); VS (2.256 cP at 20°C); CP (143.9 J/K-mol liquid at 25°C); HV (47.45 kJ/mol at 298.15K); VD (2.07); VP (15mmHg at 20°C, 10 mmHg at 14.7°C);

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported to occur under normal temperatures and pressures; can react vigorously with oxidizing materials; FP (23.3°C, 74.0°F); LFL//UFL (2.2%, 13.7%); AT (440°C, 824°F); HC (-1.8438 x 10<sup>9</sup> J/kmol); HF (-302.6 kJ/mol liquid at 25°C); H<sub>f</sub> (5.2 kJ/mol at 147.0K).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 1, Flammability 3, Reactivity 0; dangerous fire hazard when exposed to heat or flame; explosive in vapor form upon exposure to heat or flame; vapor-air mixtures are explosive above the flash point; flashback along vapor trail may occur; contact with strong oxidizers may cause fire and explosion; reacts violently with alkali and alkaline earth metals, generating highly flammable hydrogen gas; ignites on contact with potassium tert-butoxide; thermal decomposition products may include toxic oxides of carbon; use dry chemical, halon, alcohol foam, water spray or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract); eye contact (transient eye irritation with redness and pain); skin contact (dry cracking skin, defatting of the skin); ingestion (gastrointestinal discomfort, central nervous system depression, impaired liver function, hyperplasia of hematopoietic tissue).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide artificial respiration; if ingested, rinse mouth and give activated charcoal; get medical attention immediately.

**HUMAN TOXICITY DATA:** oral-woman LDLo 5700 mg/kg; mutagenic data; reproductive effects data; tumorigenic data.

**ACUTE HEALTH RISKS:** mild irritation of eyes, nose and throat; drowsiness; headache; ataxia (nosebleed); depression of central nervous system; gastrointestinal pain; abdominal cramps; nausea; vomiting; diarrhea; death from respiratory failure.

**CHRONIC HEALTH RISKS:** conjunctivitis; may cause defatting of skin; severe injury to the liver; hyperplasia of hematopoietic tissue; reproductive effects; toxic effects may be enhanced by use of alcoholic beverages.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200ppm; ACGIH TLV STEL 250 ppm (skin); OSHA PEL TWA 200 ppm (500 mg/m<sup>3</sup>); OSHA PEL STEL 250 ppm (625 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 200 ppm (500mg/m<sup>3</sup>); NISOH REL STEL 250 ppm (625mg/m<sup>3</sup>)(skin); IDLH 800 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles where splashing is possible; wear positive pressure self-contained breathing apparatus to protect against the hazardous by-products of combustion, toxic fumes and oxygen deficiency; provide a closed system of local exhaust ventilation to meet the published exposure limits; maintain an eyewash station and quick-drench facilities in work area.

**SPILL CLEAN-UP:** stop leak without risk if possible; use water spray to cool and reduce vapors, and dilute spills to form nonflammable mixtures; absorb with sand or other inert materials, and place in chemical waste containers for later disposal; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** take up with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in a sanitary landfill; EPA Waste # D001 must be in accordance with federal, state and local requirements; store in a cool, dry well-ventilated location; keep away from any area where the fire hazard may be acute; containers should be bonded and grounded for transfers to avoid static sparks; use non-sparking type tools and equipment, including explosion proof ventilation; avoid contact with heat sparks, flames, or other sources of ignition; store away from incompatible substances.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for waxes, vegetable oils, resins, cellulose esters, ethers, brake fluids, polishing compositions, and degreasing operations; useful as a chemical intermediate in organic synthesis; also used as an antiseptic.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### **n-PROPYL NITRATE (CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>ONO<sub>2</sub>, 105.11)**

**CAS/DOT IDENTIFICATION #:** 627-13-4/UN1865

**SYNONYMS:** nitric acid propyl ester, propyl nitrate.

**PHYSICAL PROPERTIES :** pale-yellow liquid; sweet, sickly odor; soluble in alcohol and ether; very slightly soluble in water; forms an azeotrope with water containing 75% C<sub>3</sub>H<sub>7</sub>NO<sub>3</sub> and a boiling point of 84.8°C; MP (< -101°C, <-150°F); BP (110°C, 230°F); DN (1.054 g/mL at 20°C); LSG (1.05); VP (18 mmHg at 20°C).

**CHEMICAL PROPERTIES:** flammable liquid; thermally unstable; strong oxidizer; reacts with oxidizing materials and combustible materials; decomposes at 175°C (347°F); FP (20°C, 68°F); LFL/UFL (2%, 100%); AT (175°C, 347°F).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 2, Flammability 3, Reactivity 3; dangerous fire hazard when exposed to heat, flame or oxidizers; explosive in vapor form; flashback along vapor trail may occur; shock-sensitive explosive; closed containers may rupture violently on heating; forms explosive mixtures with combustible materials; can be desensitized by the addition of 1-2% propane, butane, chloroform, dimethyl ether, or diethyl ether; heating to decomposition emits toxic fumes of oxides of nitrogen; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (hypotension, methemoglobinemia, cyanosis, dyspnea); contact (headache, weakness, dizziness).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin immediately with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; cyanosis; difficult breathing; headache, weakness, dizziness; anoxia, vasodilation; smooth muscle relaxation.

**CHRONIC HEALTH RISKS:** hypotension, methemoglobinemia.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 25 ppm; ACGIH TLV STEL 40 ppm; OSHA PEL TWA 25 ppm (110 mg/m<sup>3</sup>); NIOSH REL TWA 25 ppm (105 mg/m<sup>3</sup>); NIOSH REL STEL 40 ppm (170 mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** wear boots, gloves, sleeves, aprons, etc.; wear splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use appropriate foam to blanket release and suppress vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a secured, sanitary landfill; store in a cool, dry location with adequate ventilation; outside storage is preferred; separate from oxidizing materials and combustibles.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a fuel ignition promoter; used in the manufacture of rocket fuels and as an organic intermediate.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10.

## **PROPYLENE DICHLORIDE (CH<sub>3</sub>CHClCH<sub>2</sub>Cl, 113.0)**

**CAS/DOT IDENTIFICATION #:** 78-87-5/UN1279

**SYNONYMS:** alpha, beta-dichloropropane, alpha, beta-propylene dichloride, dichloro-1,2-propane, 1,2-dichloropropane, propylene chloride.

**PHYSICAL PROPERTIES :** colorless liquid; sweet, chloroform like odor; soluble in alcohol, ether, benzene, and chloroform; slightly soluble in water; miscible with organic solvents; MP (-100°C, -148°F); BP (96°C, 205°F); DN (1.159 g/mL at 25°C); LSG (1.16); ST (29 dynes/cm at 20°C); CP (149.1 J/k-mol at 25°C); HV (36.4 kJ/mol at 25°C); VD (3.9); VP (40 mmHg at 20°C, 50 mmHg at 25°C); OT (25 ppm).

**CHEMICAL PROPERTIES:** sensitive to heat; reacts with oxidizing materials, strong acids, alkalis, and active metals, such as aluminum; FP (16°C, 60°F); LFL/UFL (3.4%, 14.5%); AT (557°C, 1035°F); HC (-7,300 Btu/lb, -4100 cal/g, -170 x 10<sup>5</sup> J/kg); HF (-198.8 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; very dangerous fire hazard; poisonous gases produced in fire; flashback along vapor trail may occur; vapor may explode if ignited in a confined area; reaction with aluminum to form aluminum chloride can lead to explosions; reacts vigorously with oxidizing materials; incompatible with strong oxidizers, strong acids, and active metals; toxic combustion products may include carbon monoxide and hydrogen chloride; use water spray, carbon dioxide, dry chemical or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (narcotic effects, liver and kidney necrosis, fatty degeneration of the liver, kidney or heart); contact (irritates eyes and mucous membranes, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** no data is available for humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; drowsiness; lightheadedness; coughing; breathing difficulty; chest discomfort; conjunctival hemorrhages; liver and kidney damage; effects on blood; effects on central nervous system; heart damage.

**CHRONIC HEALTH RISKS:** no information is available on the chronic effects in humans; EPA Group B2: probable human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 75 ppm; ACGIH TLV STEL 110 ppm; OSHA PEL TWA 75 ppm (359mg/m<sup>3</sup>); OSHA PEL STEL 110 ppm; IDLH 400 ppm.

**PERSONAL PROTECTION:** wear protective coveralls and rubber footwear; wear chemical-resistant rubber gloves; wear splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; cautiously ignite paper in open areas, away from combustible materials; absorb large quantities with noncombustible materials such as dry earth or sand; flush remaining propylene dichloride with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible in dry earth, sand or vermiculite; place in a sanitary landfill or dump in closed incinerator with afterburner; dissolve in flammable solvent and atomize large amounts in a suitable combustion chamber equipped with afterburner and alkali scrubbers; store in a standard flammable liquids storage room separate from oxidizing materials and active metals; outside storage is preferred.

**REGULATORY INFORMATION:** CA2; R2-38; R3; R4; U waste # (U083); Reportable Quantity (RQ): 1000lbs (454 kg); Sfl; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** use as an oil and fat solvent; solvent in plastics, resins, and metals industries; used in dry cleaning fluids and degreasing; intermediate for perchloroethylene and carbon tetrachloride; used in insecticidal fumigant mixtures.

**KEY REFERENCES:** 3; 4; 5; 6; 8; 10; 11; 12; 14; 19.

## PROPYLENE IMINE (C<sub>3</sub>H<sub>7</sub>N, 57.11)

**CAS/DOT IDENTIFICATION #:** 75-55-8/UN1921

**SYNONYMS:** 2-methylazacyclopropane, 2-methylaziridine, methylethylenimine, 2-methylethylenimine, 1,2-propylene imine.

**PHYSICAL PROPERTIES :** colorless, oily liquid; strong, ammonia-like odor; miscible with ethanol, chloroform, and ether, soluble in water; MP (-65°C, -85°F); BP (66-67°C, 150.8-152.6°F); DN (0.8039-0.8070 g/cm<sup>3</sup> at 25°C); LSG (0.80); HV (250 Btu/lb, 139 cal/g); VD (2.0); VP (112 mmHg at 20°C, 140 mmHg at 25°C); OT (intolerable at 14 ppm).

**CHEMICAL PROPERTIES:** flammable liquid; corrosive; polymerizes on exposure to acids or acid fumes; hygroscopic liquid; reacts vigorously with strong oxidizers, acids, carbonyl

compounds, quinones, sulfonyl halides, and water; hydrolyzes in water to form methylethanolamine; FP (-10°C, 14°F); LFL/UFL (NA); AT (NA); HC (-15,500 Btu/lb, -8,600 cal/g).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating (not available); very dangerous fire hazard; flashback along vapor trail may occur; ignition of vapor in a confined area may result in explosions; containers may explode in fire; dangerous storage hazard; subject to violent polymerization on exposure to acids or acid fumes; sensitive to moisture; reacts vigorously with oxidizing materials; incompatible with acids, acid chlorides and acid anhydrides; hazardous decomposition products include carbon monoxide, carbon dioxide, and oxides of nitrogen, use carbon dioxide or dry chemicals for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose and throat, coughing, wheezing, laryngitis, burning sensation, shortness of breath, headache, dizziness, nausea, vomiting); contact (severe skin and eye irritant); ingestion (burns of the mouth and stomach).

**FIRST AID:** was eyes immediately with large amounts of water; flush skin immediately with large amounts of water and rinse with vinegar and water; if swallowed, drink large amounts of milk and water and seek prompt medical attention; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** no data available for humans.

**ACUTE HEALTH RISKS:** irritation of eyes and upper respiratory tract; headaches; dizziness; bronchitis; labored breath; pulmonary edema; destructive to tissues of mucous membranes; nausea; skin burns; burns of the mouth and stomach.

**CHRONIC HEALTH RISKS:** probable human carcinogen; implicated as brain carcinogen; mutation data reported; may cause genetic damage; no information available on reproductive or developmental effect on humans; EPA has not established a reference concentration due to inadequate data; reference dose not established by EPA.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm(skin); OSHA PEL TWA 2 ppm (5mg/m<sup>3</sup>)(skin); NOSH REL TWA (2 ppm (5mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear rubber overclothing (including boots, apron, and chemical-resistant gloves); wear chemical safety goggles or a face shield; wear positive pressure self-contained breathing apparatus; use in a fume hood.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; high efficiency particulate arrestor or charcoal filters can be used to minimize amount of carcinogen; solvent extraction, chemical destruction, or specially designed incinerators may be used to decontaminate spills; isolate and remove discharged material; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** transmit used charcoal filters contaminated with carcinogen into properly labeled, sealed plastic bags; collect waste liquids in secured, properly labeled containers or bottles; once filled, bottles should be placed in sealed plastic bags; store away from combustible materials and ignitions sources, since containers may explode in fire.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 11bs (0.454 kg); Sf2; Sf3; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a chemical intermediate in latex surface coating resins, in textile, dye and paper industries; used as an oil additive for viscosity control, high pressure performance, and oxidation resistance; use in rubber and pharmaceutical industries; used in flocculants in petroleum refining and in rocket propellant fuels.

**KEY REFERENCES:** 4; 5; 6; 7; 11; 12; 13; 14; 19.

**PROPYLENE OXIDE (C<sub>3</sub>H<sub>6</sub>O, 58.09)**

**CAS/DOT IDENTIFICATION #:** 75-56-9/UN1280

**SYNONYMS:** epoxypropane, 1,2-epoxypropane, 2,3-epoxypropane, methyl ethylene oxide, methyl oxirane, propene oxide, propylene epoxide, 1,2-propylene oxide.

**PHYSICAL PROPERTIES :** colorless liquid; sweet ether-like odor; a gas above 94°F; miscible with acetone, benzene, carbon tetrachloride, methanol, and ether; very soluble in water; MP (-112°C, -170°F); BP (34°C, 94°F); DN (0.8304 g/mL at 20°C); LSG (0.83); ST (24.5 dynes/cm); VS (0.28 cP at 25°C); CP (120.4 J/K-mol liquid at 25°C); HV (205 Btu/lb, 114 cal/g, 4.77 x 10<sup>5</sup> J/kg); VD (2.00); VP (442 mmHg at 20°C); OT (200 ppm in air).

**CHEMICAL PROPERTIES:** corrosive; low ignition energy; polymerizes exothermically; hazardous polymerization may occur due to high temperatures or contamination with highly active catalysts, aqueous acids, bases, amines, and acidic alcohols; reacts with strong acids, alkalies, salts, clay based absorbents, and combustible materials; reaction with water may lead to a runaway reaction; FP (-37°C, -35°F); LFL/UFL (2.3%, 36.0%); AT (465°C, 869°F); HC (-13,000 Btu/lb, -7221 cal/g, -302.3 x 10<sup>5</sup> J/kg); HF (-122.6 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 3, Flammability 4, Reactivity 2; very dangerous fire and explosion hazard; flashback along vapor trail may occur; closed containers may explode in fire; vapor may explode if ignited in an enclosed area; reacts explosively with epoxy resin and sodium hydroxide; forms explosive mixtures with oxygen; reacts with ethylene oxide and polyhydric alcohol to form the thermally unstable polyether alcohol; can react vigorously with oxidizing materials; incompatible with ammonium hydroxide, chlorosulfonic acid, hydrogen chloride, hydrogen fluoride, nitric acid, sulfuric acid, and oleum; decomposition emits acrid smoke and toxic fumes; use water spray, carbon dioxide, dry chemical, or alcohol foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, nausea, vomiting, mild depression of central nervous system, lung irritation, unconsciousness); contact (severe irritation of skin and eyes).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** sce-human lymphocyte 25,000 ppm; inhalation-man TCLo 1400g/m<sup>3</sup>/10M; toxic effect: central nervous system, gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of eyes, upper respiratory system and lungs; skin irritation; blistering and burns; coughing; breathing difficulty; pneumonia; pulmonary edema; headache; motor weakness; uncoordination; ataxia; mild central nervous system depressant; necrosis; coma.

**CHRONIC HEALTH RISKS:** no information is available on the chronic effects in human; EPA Group B2: probably human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 20 ppm; OSHA PEL TWA 100 ppm (240mg/m<sup>3</sup>); IDLH 400 ppm.

**PERSONAL PROTECTION:** wear special protective clothing, rubber gloves and boots; large and heavy face shields are recommended; use splash-proof safety goggles where liquid propylene oxide may contact the eyes; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in a fume hood; cautiously ignite paper in open areas away from combustible materials; dissolve large quantities in a flammable solvent such as alcohol and atomize in a suitable combustion chamber; do not use clay-based absorbents; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be subjected to ultimate disposal by controlled incineration; discharge concentrated liquid waste containing no peroxides at a controlled rate near a pilot flame; for concentrated liquid waste containing peroxides, cautiously ignite in open areas; store in a cool, dry location; outside storage is preferred; separate from acids; alkalies, salts, clay-based absorbents, and combustible materials.

**REGULATORY INFORMATION:** CA2; F7; Reportable Quantity (RQ): 100lbs (45.4 kg); Sf1; Sf2; Sf3; CW1; CW2; T799-18; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a chemical intermediate in the preparation of polyethers to form polyurethanes; used in the preparation of lubricants, surfactants, oil demulsifiers, urethane polyols, and propylene and dipropylene glycols; propylene oxide treatment is a practical method of control for salmonella in meat scraps; also used in the manufacture of detergents and as a component in brake fluids.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 10; 11; 12; 13; 14; 19.

**PYRETHRUM** ( $C_{20}H_{28}O_3/C_{21}H_{28}O_5$ ,  $C_{21}H_{30}O_3/C_{22}H_{30}O_5$ ,  $C_{21}H_{28}O_3/C_{22}H_{28}O_5$ ; 316-374)

**CAS/DOT IDENTIFICATION #:** 8003-34-7/NA

**SYNONYMS:** cinerin I or II, jasmolin I or II, pyrethrin I or II.

**PHYSICAL PROPERTIES :** brown, viscous oil or solid; soluble in common organic solvents; very slightly soluble in water; MP (NA); BP (170°C, 338°F at 0.1 mmHg); SG (approximately 1); VD (NA); VP (0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible liquid; generally stable; no conditions contributing to instability; nonvolatile; not compatible with alkaline material; FP (82-88°C, 180-190°F); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating (NA); contact with strong oxidizers may cause fires and explosions; heating to decomposition emits irritating fumes and acrid smoke; use carbon dioxide, foam, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sneezing, nasal discharge, nasal stuffiness, asthma); contact (erythema, dermatitis, papules, burning and itching sensation, swollen cheeks and eyes, skin roughening).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** oral-human LDLo 1 g/kg; oral child LDLo 750mg/kg.

**ACUTE HEALTH RISKS:** erythema; papules; pruritis; intense itching; blister formation; wheezing; sneezing; rhinitis; breathing difficulties; weakness; collapse; anaphylactic shock; swollen cheeks and eyes; irritating to mucous membranes.

**CHRONIC HEALTH RISKS:** asthma; sensitization dermatitis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; IDLH 5000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and face shields; use dust-and splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper, place in an appropriate container and burn in a fume hood; dissolve in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber.

**DISPOSAL AND STORAGE METHODS:** make packages of pyrethrum in paper and burn in a suitable combustion chamber; dissolve in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers and alkaline materials.

**REGULATORY INFORMATION:** F2; F7; F8; Reportable Quantity (RQ): 1 lb (0.454 kg); Sfl; A1; CAL.

**OTHER COMMENTS:** pyrethrum is a variable mixture of Cinerin, Jasmolin, and Pyrethrin; application as an insecticide on agricultural crops, cattle, poultry, and food cartons; used in the formulation of scabicides and parasiticides for medical and veterinary use.

**KEY REFERENCES:** 4; 5; 6; 7; 12; 16.

**PYRIDINE** (C<sub>5</sub>H<sub>5</sub>N, 79.11)

**CAS/DOT IDENTIFICATION #:** 110-86-1/UN1282

**SYNONYMS:** azabenzene, azine

**PHYSICAL PROPERTIES :** colorless to slightly yellow liquid; strong odor of ammonia; burning taste; slightly alkaline in reaction; soluble in water, alcohol, ether, petroleum ether, and fatty oils; miscible with many other organic liquids such as benzene and ligroin; a good solvent for many organic and inorganic compounds; forms an azeotropic mixture with water, boiling at 92-93°C; MP (-42°C, -44°F); BP (115°C, 240°F); DN (0.982 g/mL at 20°C); LSG (0.98); ST (36.56 mN/m at 25°C); VS (0.879 mPa-s at 25°C); CP (132.7 J/K-mol liquid at 25°C); HV (40.21 kJ/mol at 25°C); D (2.73); VP (10 mmHg at 13.2°C).

**CHEMICAL PROPERTIES:** flammable liquid; weak base; forms salts with strong acids; reacts with many acids and oxidizers; FP (20°C, 68°F); LFL/UFL (1.8%, 12.4%); AT (482°C, 900°F); HF (100.2 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 3, Flammability 3, Reactivity 0; dangerous fire hazard when exposed to heat, flame or oxidizers; severe explosion hazard in vapor form; flashback along vapor trail may occur; violent reaction with chlorosulfonic acid, chromium trioxide, dinitrogen tetroxide, nitric acid, sulfuric acid, oleum, perchromates, and silver perchlorate; reacts incandescently with fluorine; reacts with bromine trifluoride to form pyrophoric or explosive products; evolves carbon dioxide upon reaction with maleic anhydride (above 150°C); mixtures with formamide and iodine and sulfur trioxide release carbon dioxide and sulfuric acid and are storage hazards; incompatible with strong oxidizers and strong acids; combustion by-products include carbon monoxide, carbon dioxide, and oxides of nitrogen; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin and respiratory system); skin absorption (nervousness, headache, nausea); contact (eye and skin burns, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** oral-unspecified effects LD<sub>50</sub> 1500mg/kg; inhalation-unspecified effects LC<sub>50</sub> 10g/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; severe eye and skin burns; headache; nervousness; dizziness; insomnia; nausea; gastrointestinal upset; frequent urination.

**CHRONIC HEALTH RISKS:** central nervous system depression; anorexia; liver and kidney damage; dermatitis; mutation data reported; target organs: eyes, skin, central nervous system, liver, kidneys, gastrointestinal tract.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm; OSHA PEL TWA 5 ppm (15 mg/m<sup>3</sup>); NIOSH REL TWA 5 ppm (15mg/m<sup>3</sup>); IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear special protective clothing (boots, gloves, sleeves, aprons, etc.); wear splash-proof safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; dilute spills to form nonflammable mixtures but not into confined spaces such as sewers because of danger of explosion; large quantities can be collected and atomized in a suitable combustion chamber equipped with afterburner and appropriate scrubbing device.

**DISPOSAL AND STORAGE METHODS:** atomize in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; outside storage is preferred; isolate from oxidizing materials and acids.

**REGULATORY INFORMATION:** S10; R4; R5; R6; R8; D waste # (D038); U waste e# (U196); Reportable Quantity (RQ): 1000 lbs. (454 kg); Sf1; Sf3; T120-a; A1; CAL; DOT hazard class/division (3); labels (flammable liquid, poison).

**OTHER COMMENTS:** used as a solvent for anhydrous mineral salts; used in the synthesis of vitamins and drugs; denaturant for alcohol and antifreeze mixtures; dyeing assistant in textiles; synthetic intermediate in laboratory and industry.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 14.

**QUINONE** (C<sub>6</sub>H<sub>4</sub>O<sub>2</sub>, 108.1)**CAS/DOT IDENTIFICATION #:** 106-51-4/UN2587**SYNONYMS:** benzoquinone, 1,4-benzoquinone, cyclohexadienedione, 1,4-cyclohexadienedione, 2,5-cyclohexadiene-1,4-dione, 1,4-cyclohexadiene dioxide.**PHYSICAL PROPERTIES :** yellow crystals; yellow prisms from water or petroleum ether; chlorine-like odor; soluble in ethanol, ether, hot petroleum ether and alkalies; slightly soluble in water; sublimes at boiling point; MP (115.7°C, 240.3°F); BP (sublimes); DN (1.318 g/cm<sup>3</sup> at 20°C); SG (1.32); CP (129.0 J/K-mol crystal at 25°C); VD (not applicable); VP (0.1 mmHg at 25°C); OT (0.400 mg/m<sup>3</sup>).**CHEMICAL PROPERTIES:** may darken on standing; reacts vigorously with strong oxidizers; FP (37.8-93.3°C, 100-200°F); LFL/UFL (NA); AT (560°C, 1,040°F); HC (656.6 kcal/gmol at 25°C); HF (-185.7 kJ/mol at 25°C); H<sub>f</sub> (18.5 kJ/mol at 388.8K).**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 1, Flammability 2, Reactivity 1; moist material self-heats and decomposes exothermically above 60°C; incompatible with oxidizing materials; cylinder may explode in heat of fire; poisonous and irritating gases such as quinone fumes and carbon monoxide may be released in a fire; use water spray, dry chemical, carbon dioxide, or foam for firefighting purposes.**HEALTH SYMPTOMS:** inhalation (eye irritation, conjunctivitis); contact (severe skin damage, destructive to mucous membranes, skin discoloration, erythema, generalized swelling, papules, vesicles, photophobia, eye lacrimation, cornea ulceration and scarring, brownish discoloration of the cornea, and damage in corneal structure).**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.**HUMAN TOXICITY DATA:** oms-human lymphocyte 5µmol/L; sce-human lymphocyte 5µmol/L; subcutaneous-unspecified LD<sub>50</sub> 296 mg/kg.**ACUTE HEALTH RISKS:** eye irritation; conjunctivitis; discoloration of the conjunctiva and cornea; keratitis; skin irritation; skin discoloration; severe destruction to mucous membranes; erythema; swelling; formation of papules and vesicles.**CHRONIC HEALTH RISKS:** human mutation data reported; dangerous visual disturbances; skin ulcerations; necrosis; IARC Group 3: not classifiable as to carcinogenicity to humans.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; OSHA PEL TWA 0.1 ppm (0.4mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.4 mg/m<sup>3</sup>); IDLH 100 mg/m<sup>3</sup>.**PERSONAL PROTECTION:** wear protective clothing, boots, apron, etc.; wear chemical-resistant gloves; wear chemical-safety goggles; wear self-contained breathing apparatus; avoid contact with solid or dust.**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper or suitable material and ignite in safe place, such as a fume hood; dissolve large quantities in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber equipped with afterburner and scrubber; remove all sources of ignition.**DISPOSAL AND STORAGE METHODS:** pipe gas into incinerator, lower into a pit, and allow it to burn away; atomize the liquid into an incinerator; dissolve solid in a flammable

solvent and atomize large amounts in a suitable combustion chamber equipped with effluent gas cleaning device; store in a cool, dry location; keep away from strong oxidizers and other combustibles.

**REGULATORY INFORMATION:** CA2; Reportable Quantity (RQ): 10lbs (4.54 kg); Sfl1; Sf3; T120-a; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as an oxidizing agent; used in the manufacture of dyes and hydroquinone; can strengthen animal fibers and make gelatin insoluble; used in pharmaceutical industry for production of cortisone; use in polymer and resins industry; use as a tanning agent for leather industry.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 12; 13; 14; 19.

**RHODIUM** (metal fume and insoluble compounds, as Rh)(The atomic formula for rhodium metal is Rh. The atomic weight for rhodium metal is 102.91. Insoluble rhodium compounds have variable molecular formulas and variable formula weights, depending upon the specific compound.)

**CAS/DOT IDENTIFICATION #:** 7440-16-6/UN3089 (metal). Insoluble rhodium compounds have variable CAS #'s depending upon the specific compound.

**SYNONYMS:** elemental rhodium, rhodium metal. Synonyms of other insoluble rhodium compounds vary depending upon the specific compound.

**PHYSICAL PROPERTIES :** white solid of platinum group with a bluish-gray luster; harder than platinum or palladium; ductile and malleable; face-centered cubic structure; high surface reflectivity; insoluble in acids and aqua regia; soluble in fused potassium bisulfate; MP (1966°C, 3570°F); BP (3727°C, 6741°F); DN (12.41 g/cm<sup>3</sup> at 20°C); SG (12.41); CP (25.0 J/K-mol crystal at 25°C); VD (NA); VP (approximately 0 mmHg at 20°C); BHN (100).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; slowly oxidizes at 6°C (43°F); finely divided metal reacts with aqua regia; absorbs oxygen when melted and slowly oxidizes to the sesquioxide at a red heat; not attacked by fluorine, but is converted to the trihalide by bromine or chlorine at a red heat; a strong complexing agent; of the platinum group, has the highest electrical and thermal conductivity; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); H<sub>f</sub> (26.59 kJ/mol at 2237K); ER (4.51 μohm-cm at 0°C).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid in bulk form; flammable gas as dust or in powder form; finely dispersed particles form explosive mixtures in air; reacts with oxygen difluoride causing fire hazard; violent reaction with bromine trifluoride, chlorine trifluoride and bromine pentafluoride; in case of fire in the surroundings, all extinguishing agents are suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (possible sensitization of respiratory tract); skin/eye contact (no adverse effects reported in the literature); ingestion (no adverse effects reported in the literature).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, seek medical attention immediately.

## 872 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found relating to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** possible respiratory sensitization. (note: no toxic effects of rhodium metal fume and insoluble compounds have been reported in experimental animals or in man).

**CHRONIC HEALTH RISKS:** no information found concerning repeated or prolonged exposure in experimental animals or in man.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg (metal)/m<sup>3</sup>, 1 mg(insoluble compounds as Rh)/m<sup>3</sup>; OSHA PEL TWA 0.1 mg(Rh)/m<sup>3</sup> (metal, fume, insoluble compounds); NIOSH REL TWA 0.1 mg (Rhodium (as Rh))/m<sup>3</sup>; IDLH 100 mg (Rhodium (as Rh))/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including chemical-resistant gloves, apron or disposable coveralls; wear dust-proof safety goggles; a closed system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in IDLH or unknown concentrations; for extra personal protection, use a P3 filter respirator for toxic particles; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; sweep spilled substance into covered containers; moisten spill to prevent dusting; collect remaining material, then remove to a safe place.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry area with adequate ventilation; fireproof if in building; separate from oxygen difluoride; avoid sparks and open flames.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (4.1); labels (no information found).

**OTHER COMMENTS:** used as an alloy with platinum for high temperature thermocouples, laboratory crucibles, and furnace windings; protects silverware from tarnishing by acting as a corrosion-resistant electroplate; utilized in the manufacture of high-reflectivity mirrors, jewelry and headlight reflectors; spongy or black rhodium is used as a catalytic metal in many oxidation and hydrogenation reactions.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**RHODIUM** (soluble compounds, as Rh)(Soluble rhodium compounds have variable molecular formulas and variable formula weights, depending upon the specific compound. The physical and chemical properties of one specific compound, for example, hydrate rhodium trichloride, are provided. The molecular formula for this substance is Cl<sub>3</sub>Rh·xH<sub>2</sub>O. The molecular weight is reported as being greater than 209.)

**CAS/DOT IDENTIFICATION #:** 7440-16-6/UN3089 (metal)

**SYNONYMS:** Synonyms vary depending upon the specific soluble rhodium compound. (hydrated rhodium trichloride) rhodium chloride, soluble rhodium trichloride.

**PHYSICAL PROPERTIES** : Physical appearance and odor vary depending upon the specific soluble rhodium compound. (hydrated rhodium trichloride) deep-red, hygroscopic crystals; odorless solid or liquid; very soluble in water; soluble in hot ethanol; MP (100°C, 212°F) (decomposes); BP (800°C, 1472°F)(sublimes); DN/SG (>1); VD (NA); VP (<0.1 mmHg at 20°C).

**CHEMICAL PROPERTIES**: Chemical properties, reactivities, and incompatibilities vary depending upon the specific soluble rhodium compound. (hydrated rhodium chloride) rhodium chloride readily forms double salts with alkali chlorides; some decomposition may occur at temperatures above 100°C (212°F); no incompatibilities have been reported; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS**: not combustible; toxic gases and vapors (such as hydrogen chloride or chlorine) may be released upon decomposition.

**HEALTH SYMPTOMS**: inhalation (no adverse effects in humans); skin/eye contact (no adverse effects in humans); ingestion (no adverse effects in humans).

**FIRST AID**: rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, seek medical attention immediately.

**HUMAN TOXICITY DATA**: no LD<sub>50</sub>/LC<sub>50</sub> information found relating to normal routes of occupational exposure.

**ACUTE HEALTH RISKS**: has been reported to cause eye damage in animals; rhodium trichloride has also caused central nervous system damage in animals. (note; no toxic effects of soluble rhodium salts have been reported in humans).

**CHRONIC HEALTH RISKS**: no information found concerning repeated or prolonged exposure in experimental animals or in man.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 0.01 mg(soluble compounds as Rh)/m<sup>3</sup>; OSHA PEL TWA 0.001 mg (soluble compounds as Rh)/m<sup>3</sup>; NIOSH REL TWA 0.001 mg (soluble compounds as Rh)/m<sup>3</sup>; IDLH 2 mg(as Rh)/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear impervious protective clothing, including chemical-resistant gloves, apron or disposable coveralls; wear dust-proof safety goggles; a closed system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in IDLH or unknown concentrations; for extra personal protection, use a P3 filter respirator for toxic particles; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP**: ventilate area of spill; sweep solid material into covered containers; moisten first to prevent dusting; liquid containing soluble rhodium salts should be absorbed with inert materials, such as dry earth, sand, or vermiculite.

**DISPOSAL AND STORAGE METHODS**: soluble rhodium compounds may be disposed of in sealed containers in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry area; maintain adequate ventilation; fire-proof if in building; avoid sparks and open flames.

**REGULATORY INFORMATION**: A1; CAL; DOT hazard class/division (4.1); labels (no information found).

**OTHER COMMENTS:** soluble rhodium salts may be used in electroplating baths for finishing scientific instruments, radio equipment, jewelry, and camera fittings; has been utilized in laboratory research.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**RONNEL ((CH<sub>3</sub>O)<sub>2</sub>PSOC<sub>6</sub>H<sub>2</sub>Cl<sub>3</sub>, 321.54)**

**CAS/DOT IDENTIFICATION #:** 299-84-3/NA

**SYNONYMS:** O,O-deimthyl-O-2,4,5-trichlorophenyl phosphorothioate, dimethyl trichlorophenyl thiophosphate, fenchlorphos, viozene.

**PHYSICAL PROPERTIES :** white to light tan crystalline solid; a liquid above 106°F (41°C); freely soluble in acetone, carbon tetrachloride, ether, methylene chloride, toluene, and kerosene; practically insoluble in water; MP (41°C, 106°F); BP (decomposes at 760 mmHg); SG (1.49); VD (NA); VP (8 x 10<sup>-4</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** noncombustible solid; will attack some forms of plastics, rubber, and coatings; can react vigorously with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating (NA); temperatures above 150°C (300°F) may cause explosive decomposition and formation of toxic gases; contact with strong oxidizers may cause fires and explosions; extremely corrosive to some forms of plastics, rubber, and coatings; sulfur dioxide, dimethyl sulfide, trichlorophenol, and carbon monoxide may be released when heated to decomposition; use dry chemical, water spray, foam or carbon dioxide for firefighting purposes..

**HEALTH SYMPTOMS:** inhalation (salivation, tremors, diarrhea, meiosis, respiratory distress); contact (conjunctival irritation, kidney damage, liver damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** sister chromatid exchange-human lymphocyte 2mg/L.

**ACUTE HEALTH RISKS:** in animals: watering of the mouth; tremors; diarrhea; small pupils; respiratory distress; eye irritation.

**CHRONIC HEALTH RISKS:** in animals: liver and kidney damage; cholinesterase inhibition; blood plasma effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10mg/m<sup>3</sup>; OSHA PEL TWA 15 mg/m<sup>3</sup>; NIOSH REL TWA 10 mg/m<sup>3</sup>; IDLH 300 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and face shields; use dust- and splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; collect spilled material in a safe manner and deposit in sealed containers for reclamation or disposal in a secured sanitary landfill; absorb as much as possible in dry earth, sand, or vermiculite..

**DISPOSAL AND STORAGE METHODS:** absorb in noncombustible materials such as dry earth, sand or vermiculite, and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; ronnel should be placed in closed containers for storage.

**REGULATORY INFORMATION:** F5; A1; CAL.

**OTHER COMMENTS:** used as an insecticide and pest control agent for agricultural and livestock operations; used as an insecticide for fruits.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 16.

### **ROTENONE (C<sub>23</sub>H<sub>22</sub>O<sub>6</sub>, 394.45)**

**CAS/DOT IDENTIFICATION #:** 83-79-4/NA

**SYNONYMS:** 1,2,12,12a-tetrahydro-8,9-dimethoxy-2-(1-methylethenyl)-[1]benzopyrano[3,4-b]furo[2,3-h][1]benzopyran-6(6aH)-one; tubatoxin.

**PHYSICAL PROPERTIES :** colorless to red, crystalline solid; orthorhombic, six-sided plates; odorless; colorless solutions in organic solvents oxidize upon exposure and become yellow, orange and then deep red; soluble in alcohol, acetone, carbon tetrachloride, chloroform, ether, and many other organic solvents; practically insoluble in water; MP (163°C, 325°F or 185-186°C, 365-367°F for dimorphic form); BP (decomposes at 760 mmHg); DN (1.27 g/cm<sup>3</sup> at 20°C); SG (1.27); VD (NA); VP (< 4 x 10<sup>-5</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible solid; can react vigorously with strong oxidizers and alkalis; decomposes on exposure to light and air; FP (NA); LFL/UFL(NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating (not available); contact with strong oxidizers may cause fires and explosions; not compatible with alkalis; heating to decomposition emits irritating fumes; use foam, carbon dioxide, dry chemical and water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (numbness of mouth, nausea, vomiting, muscle tremors); skin absorption (incoordination, convulsions, stupor, trembling); contact (mild irritation of skin, conjunctiva).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** oral-human LDLo 143mg/kg; unreported-man LDLo 294 mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; numbness of oral mucous membrane; nausea; vomiting; gastric pain; pulmonary irritation; trembling; loss of coordination; convulsions; stupor; cessation of breathing; muscle tremors; paralysis; death.

**CHRONIC HEALTH RISKS:** fatty changes in the liver; kidney damage; tumors; may alter genetic material.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; IDLH 2500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and face shield; use dust-and splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper or other material, place in an appropriate container and cautiously burn in a fume hood; dissolve in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber.

**DISPOSAL AND STORAGE METHODS:** make packages of rotenone in paper or other flammable material and burn in a suitable combustion chamber; dissolve in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber equipped with after-burner and scrubber; store in a cool, dry location with adequate ventilation; storage should be in tightly closed containers; keep away from alkaline material and strong oxidizers.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used in the formulation of pesticides; used in the manufacture of flea powders, fly sprays, and moth-proofing agents; used as an application on agricultural crops and livestock.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 16.

### **ROUGE (FeO<sub>3</sub>, 159.70)**

**CAS/DOT IDENTIFICATION #:** not available / none

**SYNONYMS:** iron (III) oxide, iron oxide red, red iron oxide, red oxide.

**PHYSICAL PROPERTIES :** fine, red powder of ferric oxide; frequently utilized in cake form or impregnated in cloth or paper; odorless; negligible solubility in water; MP(1565°C, 2849°F); BP (no information found); DN (5.24 g/cm<sup>3</sup>); SG (5.24); CP (103.9 J/K-mol crystal at 25°C); VD (not applicable); VP(approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; can react vigorously with carbon monoxide, hydrogen peroxide, and calcium hypochlorite; FP (NA); LFL/UFL(NA); AT(NA); HC(NA); HF(-824.2 kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; not expected to be a fire hazard; forms an explosive product when reacted with carbon monoxide; reacts violently with hydrogen peroxide; violent reaction with aluminum; calcium hypochlorite, and ethylene oxide; no information found concerning hazardous decomposition products; in case of fire in surroundings, use carbon dioxide or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (impaired pulmonary function, irritates eyes, skin and upper respiratory tract); skin/eye contact (may cause irritation); ingestion (no health effects identified).

**FIRST AID:** flush eyes with plenty of water for several minutes; wash dust from skin with soap and water; remove to fresh air after breathing in large amounts; if large amounts were swallowed, give water to drink and get medical advice.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found relating to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory tract; coughing and sneezing if dust is generated and inhaled during use.

**CHRONIC HEALTH RISKS:** prolonged contact may cause irritation; cancer hazard; contains silica, crystalline-tripoli which is listed as a human lung carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10mg/m<sup>3</sup>; OSHA PEL TWA 15mg (total dust)/m<sup>3</sup>, 5mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear long sleeve protective clothing and impervious gloves; use chemical safety goggles and/or full face shield; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** carefully sweep up and remove; care should be taken to avoid dust from becoming airborne; wear suitable protective clothing during clean up procedures.

**DISPOSAL AND STORAGE METHODS:** remelt and reform or use normal disposal methods; disposal must be in accordance with federal, state, and local regulations; store in a cool, dry area; suitable for any general chemical storage area; keep containers tightly closed; do not store near direct sources of heat.

**REGULATORY INFORMATION:** no information found.

**OTHER COMMENTS:** used as a polishing or buffing agent for glass, precious metals and diamonds; utilized as a pigment for paints, rubber, linoleum, ceramics, glass and paper.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

**SELENIUM COMPOUNDS** (Selenium compounds have variable molecular formulas. The molecular formulas for sodium selenite, sodium selenate, and selenium dioxide are Na<sub>2</sub>SeO<sub>3</sub>, Na<sub>2</sub>SeO<sub>4</sub>, and SeO<sub>2</sub> respectively. Selenium compounds have variable formula weights. The formula weights for sodium selenite, sodium selenate, and selenium dioxide are 173, 188.9, and 110.9 respectively)

**CAS/DOT IDENTIFICATION #:** Selenium compounds have variable CAS #'s. The CAS # for selenium is 7782-49-2./ Selenium compounds have variable DOT identification #'s. The DOT identification # for selenium is UN2658.

**SYNONYMS:** Sodium selenite: disodium selenite, disodium selenium trioxide, selenious acid, sodium selenium oxide. Sodium selenate: disodium selenate; Selenium dioxide: selenious anhydride, selenium oxide, selenous acid anhydride.

**PHYSICAL PROPERTIES :** (Sodium selenite) colorless to white crystals; odorless; insoluble in alcohol; freely soluble in water; MP (710°C, 1310°F); BP (decomposes at 760mmHg); SG (3.1); VD (NA); VP (<0.001 mmHg at 20°C). (Sodium selenate) colorless to white crystals; odorless; very soluble in water; MP (decomposes); BP (decomposes at 760 mmHg); DN (3.098 g/cm<sup>3</sup>); SG (3.1); VD (NA); VP (<0.001 mmHg at 20°C). (Selenium dioxide) white to slightly reddish, lustrous, crystalline powder; yellow liquid; green vapor; odorless; soluble in benzene; slightly soluble in most organic solvents; very soluble in water; MP (340-350°C, 644-662°F); BP(315°C, 599°F at 760mmHg); DN (3.95 g/cm<sup>3</sup> at 15°C); SG (3.95); VD (NA); VP (1mmHg at 157.0°C).

**CHEMICAL PROPERTIES:** (selenium) burns in air with a bright blue flame forming the dioxide; combines directly with hydrogen and with the halogens (excluding iodine); oxidized to selenious acid by nitric acid, to selenic acid by sulfuric acid; reacts with many metals; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating (NA); reacts to form explosive products with metal amides; contact with acids may cause formation of poisonous hydrogen selenide gas; incompatible or reacts violently with barium carbide, bromine pentafluoride, chromic oxide, fluorine, lithium carbide, lithium silicon, metals, nickel, sodium, nitric acid, nitrogen trichloride, oxygen, potassium, potassium bromate, rubidium carbide, zinc, silver bromate, uranium, strontium carbide, and thorium carbide; toxic gases and vapors may be released in a fire involving selenium, sodium selenite, sodium selenate, and selenium dioxide; use water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (shallow breathing, irritates eyes, skin, nose, and throat); contact (chills, fever, headache, superficial skin burns, nervousness, depression); ingestion (gastrointestinal disturbances, metallic taste, garlic odor of breath, diarrhea, excessive salivation).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** IRAC Cancer Review: Group 3; EPA: selenium sulfide is Group B2, probable human carcinogen.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, nose, and throat; headache; chills; fever; dyspnea; bronchitis; chemical pneumonia; bronchial spasms; irritation of mucous membranes; loss of olfaction; indigestion; dizziness; fatigue; nosebleed; nausea; vomiting; diarrhea; tremors; abdominal pain; malaise; death.

**CHRONIC HEALTH RISKS:** paleness; coated tongue; stomach disorders; nervousness; metallic taste; garlic breath; numbness; brittle hair; excessive tooth decay and discoloration; deformed nails or loss of nails; discoloration of skin; liver damage; damage to the spleen; anemia; fluid in abdominal cavity; lack of mental alertness; listlessness; paralysis; skin rashes; skin sensitization.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg (5e)/m<sup>3</sup>; OSHA PEL TWA 0.2 mg (selenium compounds)/m<sup>3</sup>; NIOSH REL TWA 0.2 mg (selenium compounds)/m<sup>3</sup>; NIOSH IDLH 100 mg (selenium compounds)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and face shields; use dust and splash-proof safety goggles; use any self-contained breathing apparatus operated in a positive pressure mode; facilities, such as showers and eyewash fountains, should be provided within immediate work area for emergency use.

**SPILL CLEAN-UP:** ventilate area of spill; liquid containing selenium and its inorganic compounds should be absorbed in vermiculite, dry earth, or sand.

**DISPOSAL AND STORAGE METHODS:** spilled material should be encapsulated and buried in a specially designated chemical landfill; absorb as much as possible in noncombustible materials such as dry earth, sand, or vermiculite, and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; storage should be in tightly closed containers; keep away from strong oxidizers, acids, and chemically active metals.

**REGULATORY INFORMATION:** Sfl

**OTHER COMMENTS:** used in glassware industry for decolorization of fiberglass, scientific glassware, vehicular tail lights, traffic lights, and infrared equipment; used in the manufacture of photograph and photocopy devices; used in the manufacture of flame-proofing agents; used as solvents in paint and varnish removers, rubber, resin, and glue solvent; use for organic synthesis in oxidation, hydrogenation, and dehydrogenation; useful as a catalyst for hardening fats for soaps and waxes, and in the refining of copper, silver, gold, or nickel ores.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 16; 19.

**SELENIUM HEXAFLUORIDE (as Se) (SeF<sub>6</sub>, 192.96)**

**CAS/DOT IDENTIFICATION #:** 7783-79-1/UN2194

**SYNONYMS:** selenium fluoride

**PHYSICAL PROPERTIES :** colorless gas; white solid at low temperatures; sublimes before melting; not soluble in water; sublimes at  $-63.8^{\circ}\text{C}$  ( $-82.8^{\circ}\text{F}$ ); MP ( $-50.8^{\circ}\text{C}$ ,  $-59.4^{\circ}\text{F}$ ); BP ( $-35^{\circ}\text{C}$ ,  $-31^{\circ}\text{F}$ ); DN (3.27 g/mL liquid at  $-46.6^{\circ}\text{C}$ ); LSG (2.3 at  $20^{\circ}\text{C}$ ); CP (110.5 J/K-mol gas at  $25^{\circ}\text{C}$ ); VD (6.66); VP ( $>7600$  mmHg at  $20^{\circ}\text{C}$ , 651.2 mmHg at  $-48.7^{\circ}\text{C}$ , 213.1 mmHg at  $-64^{\circ}\text{C}$ , 30.4 mmHg at  $-87.5^{\circ}\text{C}$ ).

**CHEMICAL PROPERTIES:** very stable under ordinary conditions of use and storage; thermally very stable; hazardous polymerization will not occur; practically inert to water; hydrolyzes very slowly in cold water; reaction with ammonia gas at  $200^{\circ}\text{C}$  ( $392^{\circ}\text{F}$ ) yields selenium, hydrogen fluoride, and nitrogen; covalently saturated; does not attack glass; FP (not applicable); LFL/UFL (not applicable); AT (not applicable); HC (not applicable); HF ( $-1117.0$  kJ/mol gas at  $25^{\circ}\text{C}$ ).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; not combustible; NFPA rating (not rated); not expected to be a fire hazard; not expected to be an explosion hazard; heating to decomposition emits very toxic fumes of F<sup>-</sup> and (Se); in case of fire in the surroundings; use water for firefighting purposes

**HEALTH SYMPTOMS:**

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped.

**HUMAN TOXICITY DATA:** no LD50/LC50 information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:**

**CHRONIC HEALTH RISKS:**

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05 ppm (Se) (0.04 mg(Se)/m<sup>3</sup>); OSHA PEL TWA 0.05 ppm (Se) (0.04 mg(Se)/m<sup>3</sup>); NIOSH REL TWA (0.04 mg(Se)/m<sup>3</sup>); IDLH 2 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including chemical-resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles; enclose operations or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level, in high vapor concentra-

tions, wear self-contained breathing apparatus, maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak; stop flow of gas if possible; if source of leak is a cylinder, cautiously remove leaking cylinder to a safe location in open air and allow cylinder to empty; if in solid form, collect spilled material and deposit in sealed containers for disposal in a secured, sanitary landfill.

**DISPOSAL AND STORAGE METHODS:** solid may be disposed of in sealed containers in a secured sanitary landfill; if flow of gas cannot be stopped, allow gas cylinder to empty; store in a cool, dry location; storage should be in closed containers with adequate ventilation; keep away from heat, sparks, and flame.

**REGULATORY INFORMATION:** A1; AS; CAL; DOT hazard class/division (2.3); label (poison gas).

**OTHER COMMENTS:** use as a gaseous electric insulator; utilized during the production of selenium hydroxide, hydrofluoric acid, selenium and nitrogen.

**KEY REFERENCES:** 3; 4; 5; 6; 8; 9; 12; 16; 19.

### **SILICA, AMORPHOUS, PRECIPITATED AND GEL (SiO<sub>2</sub>, 60.1)**

**CAS/DOT IDENTIFICATION #:** 112926-00-8/none

**SYNONYMS:** precipitated silica.

**PHYSICAL PROPERTIES :** blue crystalline solid; turns pink on contact with water; odorless; negligible solubility in water; MP (no information found); BP (no information found); DN/SG (1.1); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; no reactivities and/or incompatibilities have been specified in the literature; no hazardous decomposition products have been reported.

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); not expected to be a fire hazard; not expected to be an explosion hazard; no unusual fire and explosion hazards have been specified in the literature; in case of fire in the surroundings, use media appropriate for surrounding fire.

**HEALTH SYMPTOMS:** inhalation (cough, shortness of breath, wheezing, progressive impairment of pulmonary function, progressive respiratory symptoms (silicosis)); contact (scarring of the lungs, fibrotic nodules in the eye).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash contaminated skin with plenty of soap and water; if breathing is difficult, provide oxygen; provide artificial respiration if breathing has stopped in case of ingestion, drink water to dilute; seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** exposure to very high levels of Silica, Cristobalite can cause a serious lung disease called Silicosis; Simple Silicosis may only cause changes in chest x-ray

with severe cough, shortness of breath, wheezing, decreased pulmonary function, fever, fatigue, chest pains, and loss of appetite.

**CHRONIC HEALTH RISKS:** exposure to Silica, Cristobalite over a long period of time can also result in Silicosis; Silicosis can develop in a few weeks at very high exposures or it may occur over many years at lower exposures; may cause a progressive and sometimes fatal pulmonary fibrosis (lung scarring); characterized by the presence of nodulation in the lungs; the development of Silicosis may increase the changes of getting tuberculosis; has been shown to cause cancer in animals; limited evidence of carcinogenicity in humans; may also have the potential for causing reproductive damage in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 80mg/m<sup>3</sup>/% SiO<sub>2</sub>; NIOSH REL TWA 6 mg/m<sup>3</sup>; IDLH (no information found).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use dust-proof safety goggles and face shield when working with powders or dust; a closed system of local exhaust ventilation should be maintained to prevent the accumulation or recirculation of free silica dust into general workplace; for increased protection, use self-contained breathing apparatus operated in positive-pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; sweep or shovel into container for later disposal; minimize dust dispersion by removing dust with a water hose or vacuum with a high-efficiency particulate filter; use wet sweeping instead of dry sweeping.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in a secured, sanitary landfill; dispose of in accordance with federal, state and local regulations; storage should be in tightly closed containers in a cool, dry location; use only with adequate ventilation.

**REGULATORY INFORMATION:** A1; DOT classification (none); label (none required).

**OTHER COMMENTS:** amorphous silica may be liberated during preparation of crushing, screening, calcining, and packing operations for industrial processes; used in the manufacture of insulating materials including firebrick, insulation blocks, pipe coverings, and roofing felt; useful as a filter medium and clarifying agent in food and beverage manufacture, including sugar refining, brewing, soft drinks, and purification of oils and fats; other important uses include ceramics, paper coating, chromatography, refractories, a mild abrasive, an absorbent, and an extender in paints, rubber, and plastic products.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 16.

## **SILICA, AMORPHOUS, DIATOMACEOUS EARTH (SiO<sub>2</sub>, 60.09)**

**CAS/DOT IDENTIFICATION #:** 61790-53-2/none

**SYNONYMS:** amorphous silica, diatomaceous earth, diatomaceous silica, diatomite, infusorial earth.

**PHYSICAL PROPERTIES :** soft, bulky, solid material (88% amorphous silica); composed of skeletons of small aquatic plants related to algae (diatoms); available as white to buff colored blocks, bricks, powder, etc.; odorless solid; insoluble in water; insoluble in acids except hydrofluoric acid; soluble in strong alkalies; capable of absorbing 1.5-4 times its weight of wa-

ter; also has high oil absorption capacity; MP (1700°C, 3100°F); BP (NA); DN (1.9-2.35 g/cm<sup>3</sup>); BULK DN (5-15 lb/ft<sup>3</sup>); SG (1.9-2.35); VD (NA); VP (0 mmHg approximately at 20°C).

**CHEMICAL PROPERTIES:** stable at high temperatures; ability to withstand large and rapid temperature changes; chemically inert; poor conductor of sound, heat, and electricity; no hazardous decomposition products; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (none); contact with fluorine, oxygen difluoride, and chlorine trifluoride will cause fire; employees must be trained and equipped to fight fires, as stated in OSHA 1910.156; extinguish fire using an agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, shortness of breath, wheezing, progressive impairment of pulmonary function, progressive respiratory symptoms (silicosis)); contact (scarring of the lungs, fibrotic nodules in the eye).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash contaminated skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; begin rescue breathing if breathing has stopped and administer CPR if heart action has stopped; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** exposure to very high levels of Silica, Cristobalite can cause a serious lung disease called Silicosis; Simple Silicosis may only cause changes in chest x-ray with severe cough, shortness of breath, wheezing, decreased pulmonary function, fever, fatigue, chest pains, and loss of appetite.

**CHRONIC HEALTH RISKS:** exposure to Silica, Cristobalite over a long period of time can also result in Silicosis; Silicosis can develop in a few weeks at very high exposures or it may occur over many years at lower exposures; may cause a progressive and sometimes fatal pulmonary fibrosis (lung scarring); characterized by the presence of nodulation in the lungs; the development of Silicosis may increase the changes of getting tuberculosis; has been shown to cause cancer in animals; limited evidence of carcinogenicity in humans; may also have the potential for causing reproductive damage in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10mg(total dust)/m<sup>3</sup>; 3 mg(respirable dust)/m<sup>3</sup>; OSHA PEL TWA 80mg/m<sup>3</sup>/% SiO<sub>2</sub>; NIOSH REL TWA 6 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use dust-proof safety goggles and face shield when working with powders or dust; a closed system of local exhaust ventilation should be maintained to prevent the accumulation or recirculation of free silica dust into general workplace; for increased protection, use self-contained breathing apparatus operated in positive-pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; collect powdered material in a cautious manner and deposit in sealed containers; dustless methods of cleaning such as vacuuming or washing down of water should be used; avoid cleaning by blowing with compressed air or dry sweeping; employees must be properly trained and equipped to clean-up spills; OSHA 1910.120 (q) may be applicable.

**DISPOSAL AND STORAGE METHODS:** amorphous silica may be disposed of in a secured sanitary landfill; treat whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; must be

stored to avoid contact with strong oxidizers (such as chlorine, bromine and fluorine), manganese trioxide, oxygen difluoride, hydrogen peroxide, acetylene, and ammonia.

**REGULATORY INFORMATION:** A1; A3; CAL.

**OTHER COMMENTS:** amorphous silica may be liberated during preparation of crushing, screening, calcining, and packing operations for industrial processes; used in the manufacture of insulating materials including firebrick, insulation blocks, pipe coverings, and roofing felt; useful as a filter medium and clarifying agent in food and beverage manufacture, including sugar refining, brewing, soft drinks, and purification of oils and fats; other important uses include ceramics, paper coating, chromatography, refractories, a mild abrasive, an absorbent, and an extender in paints, rubber, and plastic products.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 16.

### **SILICA, CRYSTALLINE CRISTOBALITE, RESPIRABLE DUST (SiO<sub>2</sub>, 60.09)**

**CAS/DOT IDENTIFICATION #:** 14464-46-1/none

**SYNONYMS:** 43-63C, alpha-cristobalite, calcined diatomaceous earth, calcined diatomite, cristobalite, crysvarl, metacristobalite, W006, WGL 300.

**PHYSICAL PROPERTIES :** white, cubic-system crystals formed from quartz or amorphous silica at temperatures above 1000°C (1832°F); odorless solid; transparent and tasteless; may be a component of many mineral dusts; practically insoluble in water or acid, except hydrofluoric acid; MP (1600°C, 2912°F); BP (2230°C, 4046°F); SG (2.66); VD (NA); VP (0 mmHg approximately at 20°C).

**CHEMICAL PROPERTIES:** stable at high temperatures; attacked by hydrogen fluoride; can react vigorously with powerful oxidizing agents; no specific conditions contributing to instability; no hazardous decomposition products; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (none); contact with powerful oxidizing agents such as fluorine, chlorine, bromine, chlorine trifluoride, oxygen difluoride, manganese trioxide, hydrogen peroxide, etc. may cause fires; violent reactions occur on contact with acetylene and ammonia; no hazardous decomposition products; extinguish fire using an agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, shortness of breath, wheezing, progressive impairment of pulmonary function, progressive respiratory symptoms (silicosis)); contact (scarring of the lungs, fibrotic nodules in the eye).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash contaminated skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; begin rescue breathing if breathing has stopped and administer CPR if heart action has stopped; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 16mppcf/8H/17.9Y intermittent; toxic effects: lung, thorax, or respiration - fibrosis, focal (pneumoconiosis); lung, thorax, or respiration-cough; lung, thorax, or respiration-dyspnea.

**ACUTE HEALTH RISKS:** exposure to very high levels of Silica, Cristobalite can cause a serious lung disease called Silicosis; Simple Silicosis may only cause changes in chest x-ray

with severe cough, shortness of breath, wheezing, decreased pulmonary function, fever, fatigue, chest pains, and loss of appetite.

**CHRONIC HEALTH RISKS:** exposure to Silica, Cristobalite over a long period of time can also result in Silicosis; Silicosis can develop in a few weeks at very high exposures or it may occur over many years at lower exposures; may cause a progressive and sometimes fatal pulmonary fibrosis (lung scarring); characterized by the presence of nodulation in the lungs; the development of Silicosis may increase the changes of getting tuberculosis; has been shown to cause cancer in animals; limited evidence of carcinogenicity in humans; may also have the potential for causing reproductive damage in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5mg(respirable dust)/m<sup>3</sup>; OSHA PEL TWA 10mg(respirable dust)/m<sup>3</sup> divided by [2(% Silicon Dioxide + 2)]; NIOSH REL TWA 0.5 mg(respirable dust)/m<sup>3</sup>; IDLH 25 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use dust-proof safety goggles and face shield when working with powders or dust; a closed system of local exhaust ventilation should be maintained to prevent the accumulation or recirculation of free silica dust into general workplace; for increased protection, use self-contained breathing apparatus operated in positive-pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; collect powdered material in a cautious manner and deposit in sealed containers; dustless methods of cleaning such as vacuuming or washing down of water should be used; avoid cleaning by blowing with compressed air or dry sweeping; employees must be properly trained and equipped to clean-up spills; OSHA 1910.120 (q) may be applicable.

**DISPOSAL AND STORAGE METHODS:** crystalline silica may be disposed of in a secured sanitary landfill; treat whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; must be stored to avoid contact with strong oxidizers (such as chlorine, bromine and fluorine), manganese trioxide, oxygen difluoride, hydrogen peroxide, acetylene, and ammonia.

**REGULATORY INFORMATION:** A1; A3.

**OTHER COMMENTS:** used in the manufacture of water glass, refractories and building products, abrasives in scoring and polishing soaps and powders, ceramics, and enamels; useful in metallurgy industry for foundry molds and iron and steel castings; also used in the manufacture of fiberglass for electrical insulation, and in decolorizing and purifying oils.

**KEY REFERENCES:** 3; 4; 5; 6; 15; 16; 18.

## SILICA, CRYSTALLINE QUARTZ, RESPIRABLE DUST (SiO<sub>2</sub>, 60.09)

**CAS/DOT IDENTIFICATION #:** 14808-60-7/none

**SYNONYMS:** agate, alpha-quartz, amethyst, crystallized silicon dioxide, flint, onyx, quartz, rock crystal, rose quartz, sand, silica dust, silica flour (powdered crystalline silica), tiger-eye.

**PHYSICAL PROPERTIES :** white to reddish crystals; odorless, tasteless solid; component of many mineral dusts; practically insoluble in water or acids, except hydrofluoric acid;

insoluble in organic solvents; MP (1710°C, 3110°F); BP (2230°C, 4046°F); DN (2.6 g/cm<sup>3</sup>); SG (2.66); CP (44.4 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg approximately at 20°C).

**CHEMICAL PROPERTIES:** stable below 8°C (46°F); low (α-) quartz is stable at room temperature; transforms to high (β-) quartz at 5°C (41°F); alpha and beta forms are related by small rotations of the SiO<sub>4</sub> tetrahedron; dissolved by hydrofluoric acid, forming the gas silicon tetrafluoride; piezoelectric (capable of creating electric energy by application of very high pressures) and pyroelectric; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-910.7 kJ/mol crystal at 25°C); H<sub>f</sub> (8.51 kJ/mol at 1883K).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (none); contact with powerful oxidizers (fluorine, chlorine trifluoride, manganese trioxide, oxygen difluoride, hydrogen peroxide, etc.) may cause fires; incompatible with acetylene, ammonia, and vinyl acetate; no hazardous decomposition products; employees must be trained and equipped to fight fires, as stated in OSHA 1910.156; extinguish fire using an agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, shortness of breath, wheezing, progressive impairment of pulmonary function, progressive respiratory symptoms (silicosis), liver effects); contact (silica-containing nodules in the lungs, fibrotic nodules in the eye).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash contaminated skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; begin rescue breathing if breathing has stopped and administer CPR if heart action has stopped; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** inhalation-human TClO 16mppcf/8H/17.9Y intermittent; toxic effects: lung, thorax, or respiration - fibrosis, focal (pneumoconiosis); lung, thorax, or respiration-cough; lung, thorax, or respiration-dyspnea; inhalation-human LClO 300µg/m<sup>3</sup>/10Y-intermittent; toxic effects: liver-other changes; micronucleus test-human lung 40µg/cm<sup>2</sup>.

**ACUTE HEALTH RISKS:** exposure to very high levels of Silica, Cristobalite can cause a serious lung disease called Silicosis; Simple Silicosis may only cause changes in chest x-ray with severe cough, shortness of breath, wheezing, decreased pulmonary function, fever, fatigue, chest pains, and loss of appetite.

**CHRONIC HEALTH RISKS:** exposure to Silica, Cristobalite over a long period of time can also result in Silicosis; Silicosis can develop in a few weeks at very high exposures or it may occur over many years at lower exposures; may cause a progressive and sometimes fatal pulmonary fibrosis (lung scarring); characterized by the presence of nodulation in the lungs; the development of Silicosis may increase the changes of getting tuberculosis; has been shown to cause cancer in animals; limited evidence of carcinogenicity in humans; may also have the potential for causing reproductive damage in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.100mg(respirable dust)/m<sup>3</sup>; OSHA PEL TWA 250mppcf(respirable dust)/(%SiO<sub>2</sub> + 5) or 10mg (respirable dust/m<sup>3</sup>/(% SiO<sub>2</sub> + 2); NIOSH REL TWA 0.050 mg(respirable dust)/m<sup>3</sup>; IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use dust-proof safety goggles and face shield when working with powders or dust; a closed system of local exhaust ventilation should be maintained to prevent the accumulation or recirculation of free silica dust into general workplace; for increased protection, use self-contained breathing apparatus operated in positive-pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; collect powdered material in a cautious manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; avoid cleaning by dry-sweeping; a high efficiency particulate absolute (HEPA) filter should be used when vacuuming, not a standard shop vacuum; employees must be properly trained and equipped to clean-up spills; OSHA 1910.120 (q) may be applicable.

**DISPOSAL AND STORAGE METHODS:** crystalline silica may be disposed of in a secured sanitary landfill; treat whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; must be stored to avoid contact with strong oxidizers (such as chlorine, bromine and fluorine), manganese trioxide, oxygen difluoride, hydrogen peroxide, acetylene, and ammonia.

**REGULATORY INFORMATION:** A1; A3.

**OTHER COMMENTS:** used in the manufacture of glass, porcelain, and pottery; used in the preparation of refractory, grinding, and scouring compounds; useful in such operations as metal casting, sand blasting and granite cutting.

**KEY REFERENCES:** 3; 4; 5; 6; 8; 15; 16; 18.

## **SILICA, CRYSTALLINE TRIPOLI (AS QUARTZ), RESPIRABLE DUST (SiO<sub>2</sub>, 60.09)**

**CAS/DOT IDENTIFICATION #:** 1317-95-9/none

**SYNONYMS:** finely ground silica, randanite, silica four, tripoli.

**PHYSICAL PROPERTIES :** finely granulated, white or gray, porous siliceous rock; particles range in size from less than 0.1 $\mu$ m to about 7 $\mu$ m; appear rounded in the microscope, but the x-ray diffraction pattern is that of quartz; odorless, tasteless solid; practically insoluble in water or mineral acids, except hydrogen fluoride, soluble in molten alkali when finely divided; insoluble in organic solvents; MP (1710°C, 3110°F); BP (2230°C, 4046°F); DN (2.6 g/cm<sup>3</sup>); SG (2.66); VD (NA); VP (0 mmHg approximately at 20°C).

**CHEMICAL PROPERTIES:** stable at high temperatures; high heat and shock resistance; high dielectric constant; combines chemically with most metallic oxides; readily dissolves in hydrofluoric acid, forming the gas silicon tetrafluoride, slowly attacked by heating with concentrated phosphoric acid; no specific conditions contributing to instability; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (none); incompatible with strong oxidizers such as fluorine, chlorine trifluoride, manganese trioxide, oxygen difluoride, and hydrogen peroxide; no hazardous decomposition products; employees must be trained and equipped to fight fires, as stated in OSHA 1910.156; extinguish fire using an agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, shortness of breath, wheezing, progressive impairment of pulmonary function, progressive respiratory symptoms (silicosis)); contact (scarring of the lungs, fibrotic nodules in the eye).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash contaminated skin with plenty of soap and water; if breathing is difficult, remove to fresh

air and provide oxygen; begin rescue breathing if breathing has stopped and administer CPR if heart action has stopped; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** exposure to very high levels of Silica, Cristobalite can cause a serious lung disease called Silicosis; Simple Silicosis may only cause changes in chest x-ray with severe cough, shortness of breath, wheezing, decreased pulmonary function, fever, fatigue, chest pains, and loss of appetite.

**CHRONIC HEALTH RISKS:** exposure to Silica, Cristobalite over a long period of time can also result in Silicosis; Silicosis can develop in a few weeks at very high exposures or it may occur over many years at lower exposures; may cause a progressive and sometimes fatal pulmonary fibrosis (lung scarring); characterized by the presence of nodulation in the lungs; the development of Silicosis may increase the changes of getting tuberculosis; has been shown to cause cancer in animals; limited evidence of carcinogenicity in humans; may also have the potential for causing reproductive damage in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.100mg(of contained respirable quartz dust)/m<sup>3</sup>; OSHA PEL TWA 250mppcf(respirable dust)/(%SiO<sub>2</sub> + 5) or 10mg (respirable dust)/m<sup>3</sup>/(% SiO<sub>2</sub> + 2); NIOSH REL TWA 0.050 mg(respirable dust)/m<sup>3</sup>; IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use dust-proof safety goggles and face shield when working with powders or dust; a closed system of local exhaust ventilation should be maintained to prevent the accumulation or recirculation of free silica dust into general workplace; for increased protection, use self-contained breathing apparatus operated in positive-pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; collect powdered material in a cautious manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; avoid cleaning by dry-sweeping; a high efficiency particulate absolute (HEPA) filter should be used when vacuuming, not a standard shop vacuum; employees must be properly trained and equipped to clean-up spills; OSHA 1910.120 (q) may be applicable.

**DISPOSAL AND STORAGE METHODS:** crystalline silica may be disposed of in a secured sanitary landfill; treat whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; must be stored to avoid contact with strong oxidizers (such as chlorine, bromine and fluorine), manganese trioxide, oxygen difluoride, hydrogen peroxide, acetylene, and ammonia.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** main use for tripoli is as a buffing compound for silver, copper, brass, zinc, and aluminum; it is frequently incorporated into a waxy matrix for this purpose; also used as a filler for paint, rubber, and plastic.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 15; 16; 18.

**SILICA, CRYSTALLINE TRIDYMITE, RESPIRABLE DUST (SiO<sub>2</sub>, 60.09)**

**CAS/DOT IDENTIFICATION #:** 15468-32-3/none

**SYNONYMS:** alpha-tridymite, christensenite, tridymite, tridymite 118.

**PHYSICAL PROPERTIES** : white or colorless platelets or orthorhombic crystals; formed from quartz at temperatures greater than 870°C (1598°F), with a 16.2% increase in volume; odorless, tasteless solid; insoluble in water and most acids but dissolves in hydrofluoric acids; insoluble in organic solvents; unlike quartz, it is soluble in boiling sodium carbonate solution; MP (1710°C, 3110°F); BP (2230°C, 4046°F); DN (2.28-2.3 g/cm<sup>3</sup>); SG (2.3); CP (44.4 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg approximately at 20°C); MOHS HARDNESS (7).

**CHEMICAL PROPERTIES**: stable from 870-914C (1598-1677°F) at atmospheric pressure; persists as a meta-stable phase below 8°C (46.4°F); forms low tridymite below 1°C (34°F) and middle tridymite from 117-1°C (242.6-34°F); dissolved by hydrofluoric acid, forming the gas silicon tetrafluoride; slowly attacked by heating with concentrated phosphoric acid; rarely attacked by alkalis; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-910.7 kJ/mol crystal at 25°C); H<sub>f</sub> (8.51 kJ/mol at 1883K).

**EXPLOSION and FIRE CONCERNS**: noncombustible solid; NFPA rating (none); contact with powerful oxidizers (fluorine, chlorine trifluoride, manganese trioxide, oxygen difluoride, hydrogen peroxide, etc.) may cause fires; incompatible with acetylene, ammonia, and vinyl acetate; no hazardous decomposition products; employees must be trained and equipped to fight fires, as stated in OSHA 1910.156; extinguish fire using an agent suitable for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (cough, shortness of breath, wheezing, progressive impairment of pulmonary function, progressive respiratory symptoms (silicosis)); contact (scarring of the lungs, fibrotic nodules in the eye).

**FIRST AID**: immediately flush eyes with large amounts of water for several minutes; wash contaminated skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; begin rescue breathing if breathing has stopped and administer CPR if heart action has stopped; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA**: inhalation-human TCLo 16mppcf/8H/17.9Y-intermittent; toxic effects: lung, thorax, or respiration-fibrosis, pneumoconiosis; lung, thorax, or respiration-cough; sister chromatid exchange-human lymphocyte 13,514µg/kg.

**ACUTE HEALTH RISKS**: exposure to very high levels of Silica, Cristobalite can cause a serous lung disease called Silicosis; Simple Silicosis may only cause changes in chest x-ray with severe cough, shortness of breath, wheezing, decreased pulmonary function, fever, fatigue, chest pains, and loss of appetite.

**CHRONIC HEALTH RISKS**: exposure to Silica, Cristobalite over a long period of time can also result in Silicosis; Silicosis can develop in a few weeks at very high exposures or it may occur over many years at lower exposures; may cause a progressive and sometimes fatal pulmonary fibrosis (lung scarring); characterized by the presence of nodulation in the lungs; the development of Silicosis may increase the changes of getting tuberculosis; has been shown to cause cancer in animals; limited evidence of carcinogenicity in humans; may also have the potential for causing reproductive damage in humans.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 0.100mg(respirable dust)/m<sup>3</sup>; OSHA PEL TWA 250mppcf(respirable dust)/2(%SiO<sub>2</sub> + 5) or 10mg (respirable dust)/m<sup>3</sup>/2(% SiO<sub>2</sub> + 2); NIOSH REL TWA 0.050 mg(respirable dust)/m<sup>3</sup>; IDLH 25 mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use dust-proof safety goggles and face shield when working with powders or dust; a closed system of local exhaust ventilation should be

maintained to prevent the accumulation or recirculation of free silica dust into general workplace; for increased protection, use self-contained breathing apparatus operated in positive-pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; collect powdered material in a cautious manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; avoid cleaning by dry-sweeping; a high efficiency particulate absolute (HEPA) filter should be used when vacuuming, not a standard shop vacuum; employees must be properly trained and equipped to clean-up spills; OSHA 1910.120 (q) may be applicable.

**DISPOSAL AND STORAGE METHODS:** crystalline silica may be disposed of in a secured sanitary landfill; treat whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; must be stored to avoid contact with strong oxidizers (such as chlorine, bromine and fluorine), manganese trioxide, oxygen difluoride, hydrogen peroxide, acetylene, and ammonia.

**REGULATORY INFORMATION:** A1; A3.

**OTHER COMMENTS:** tridymite and cristobalite generally occur naturally together; both are used in the manufacture of water glass, refractories, abrasives, ceramics, enamels, and in scouring and grinding compounds; tridymite, as well as cristobalite, is formed by heating silica to high temperatures; the resulting products, due to their ability to withstand large and rapid temperature changes, are used in insulation, filters, and furnace linings.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8.

## **SILICA, FUSED, RESPIRABLE DUST (SiO<sub>2</sub>, 60.09)**

**CAS/DOT IDENTIFICATION #:** 60676-86-0/none

**SYNONYMS:** amorphous quartz, amorphous silica, cryptocrystalline quartz, fused quartz, fused silica, fuselex, microcrystalline quartz, quartz, glass, quartz sand, silicon dioxide, silicone dioxide, suprasil, vitreous silica.

**PHYSICAL PROPERTIES :** made up of spherical submicroscopic particles under 0.1 micron in size; melts to a glass with lowest known coefficient of expansions; transparent and tasteless; practically insoluble in water; soluble in molten alkali oxides; readily dissolved in hydrofluoric or a mixture of hydrofluoric and nitric acids; MP (1410°C, 2570°F); BP (2354.4°C, 4270°F); DN (2.33 g/cm<sup>3</sup> at 25°C); SG (2.33); AVERAGE HC (0.1774 cal/g°C at 16-100°C); LATTICE CONSTANT (5.41987 x 10<sup>-8</sup> cm); VD (NA); VP (0 mmHg approximately at 20°C).

**CHEMICAL PROPERTIES:** stable at high temperatures; ability to withstand large and rapid temperature changes; chemically inert; high electrical resistance; FP (NA); LFL/UFL (NA); AT (NA); COVALENT BOND IONIZATION ENERGY AT 0K (1.2 eV); INTRINSIC RESISTIVITY AT 300K (0.23 megohm); ELECTRON MOBILITY AT 300K (1500 cm<sup>2</sup>/volt/sec); INTRINSIC CHARGE DENSITY AT 300K (1.5 x 10<sup>10</sup>); ELECTRON DIFFUSION CONSTANT AT 300K (38).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (none); burns in fluorine and chlorine; incompatible with oxidizers, calcium, cesium carbide, and alkaline carbonates; decomposes at temperatures over 200°C to produce carbon monoxide; employees must be trained and equipped to fight fires, as stated in OSHA 1910.156; extinguish fire using an agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, shortness of breath, wheezing, progressive impairment of pulmonary function, progressive respiratory symptoms (silicosis)); contact (scarring of the lungs, fibrotic nodules in the eye).

**FIRST AID:** immediately flush eyes with large amounts of water for several minutes; wash contaminated skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; begin rescue breathing if breathing has stopped and administer CPR if heart action has stopped; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** severe acute bilateral pulmonary edema; acute pneumonitis; dyspnea (shortness of breath); fever; respiratory distress syndrome; hepatic inflammation; renal failure; thoracic aches; rheumatic complaints.

**CHRONIC HEALTH RISKS:** no specific information found; targets the liver and lungs.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.100mg(respirable dust)/m<sup>3</sup>; OSHA PEL TWA 250mppcf (respirable dust)/(% SiO<sub>2</sub> + 5) or 10mg (respirable dust)/m<sup>3</sup>/(% SiO<sub>2</sub> + 2); NIOSH REL TWA 0.050 mg(respirable dust)/m<sup>3</sup>; IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use dust-proof safety goggles and face shield when working with powders or dust; a closed system of local exhaust ventilation should be maintained to prevent the accumulation or recirculation of free silica dust into general workplace; for increased protection, use self-contained breathing apparatus operated in positive-pressure mode; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; collect powdered material in a cautious manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; avoid cleaning by dry-sweeping; a high efficiency particulate absolute (HEPA) filter should be used when vacuuming, not a standard shop vacuum; employees must be properly trained and equipped to clean-up spills; OSHA 1910.120 (q) may be applicable.

**DISPOSAL AND STORAGE METHODS:** crystalline silica may be disposed of in a secured sanitary landfill; treat whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local regulations; store in a cool, dry location; maintain adequate ventilation; must be stored to avoid contact with strong oxidizers (such as chlorine, bromine and fluorine), manganese trioxide, oxygen difluoride, hydrogen peroxide, acetylene, and ammonia.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as an ablative material (i.e., any material that posses a capability for rapidly dissipating heat from a substrate) in rocket engines, spacecraft, etc.; also used as fibers in reinforced plastics; used in special camera lenses.

**KEY REFERENCES:** 3; 4; 5; 6; 7.

### **MICA (RESPIRABLE DUST) (NA, 797 approximately)**

**CAS/DOT IDENTIFICATION #:** 12001-26-2/none

**SYNONYMS:** biotite, lepidolite, margarite, muscovite, phlogopite, roscoelite, zimmwaldite.

**PHYSICAL PROPERTIES** : light gray to dark flakes or particles; sheets of hydrous silicates; odorless; water-insoluble; MP (1500°C, 2731°F); BP (NA); DN (2.6-3.2 g/cm<sup>3</sup>); SG (2.6-3.2); VP (0 mmHg approximately); MOHS HARDNESS (2.8-3.2).

**CHEMICAL PROPERTIES**: noncombustible solid; generally resistant to chemical attack; exceptions are muscovite (which decomposes in hydrofluoric acid) and phlogopite (which is mildly attacked by hydrochloric acid and decomposes in hot sulfuric acid); it is dielectric; FP (NA); LFL/UFL (NA); AT (NA); pH (neutral); IR (1.58).

**EXPLOSION and FIRE CONCERNS**: mica itself does not burn; NFPA rating (NA); no incompatibilities and reactivities reported; for firefighting purposes, use an agent suitable for type of surrounding fire.

**HEALTH SYMPTOMS**: inhalation (irritates eyes, irritates lungs, lung scarring, shortness of breath, pneumoconiosis); contact (coughing, weakness, low weight).

**FIRST AID**: wash eyes immediately with large amounts of water; provide oxygen or respiratory support; wash contaminated skin with soap and water.

**HUMAN TOXICITY DATA**: no toxicity values reported in humans.

**ACUTE HEALTH RISKS**: no acute (short-term) health effects are known at this time.

**CHRONIC HEALTH RISKS**: irritation of eyes; pneumoconiosis; coughing; dyspnea (breathing difficulty); lung scarring (fibrosis); abnormal chest x-ray; weakness; weight loss.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 3m(respirable dust)/m<sup>3</sup>; OSHA PEL TWA 20 mppcf (respirable dust); NIOSH REL TWA 3 mg (respirable dust)/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear full protective clothing (suits, gloves, footwear, headgear); wear dust-proof safety goggles when working with powders or dust, unless full face-piece respiratory protection is worn; use self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP**: ventilate area of spill or release; collect powdered material in a convenient and safe manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; do not dry sweep; a high efficiency particulate air (HEPA) filter should be used when vacuuming.

**DISPOSAL AND STORAGE METHODS**: collect powdered material, deposit in sealed containers and dispose of in a sanitary landfill.

**REGULATORY INFORMATION**: A1; A3; CAL.

**OTHER COMMENTS**: used in aircraft construction, paper and paint manufacture, and in the electric industry; other uses include electrical equipment, vacuum tubes, incandescent lamps, windows in high-temperature equipment, filler in exterior paints, cosmetics, roofing, rubber, specialty paper for insulation and filtration and wallpaper and wallboard joint cement; mica powder is used in the manufacturing of electric cables, welding electrodes, bitmunized cardboard, paints and plastics, dry lubricants, dielectric dressings, and flameproof insulators; vermiculite is most commonly used as an insulating material in the building industry; lepidolite is used in the glass and ceramic industries.

**KEY REFERENCES**: 4; 5; 6; 7; 15.

**SOAPSTONE, TOTAL DUST (3MgO-4SiO<sub>2</sub>-H<sub>2</sub>O, 379.3)**

CAS/DOT IDENTIFICATION #: none/none

**SYNONYMS:** massive talc, silicates: soapstone (ACGIH:OSHA), soapstone silicate, steatite.

**PHYSICAL PROPERTIES :** white to grayish-white powder; greasy, slippery solid; odorless; insoluble in water, cold acids or in alkalies; unctuous (e.g., oily or greasy), and adheres readily to the skin; may be harder when impure; MP (NA); BP (NA); DN (2.7-2.8 g/cm<sup>3</sup>); SG (2.7-2.8); VD (NA); VP (0 mmHg approximately); MOHS HARDNESS (1-1.5).

**CHEMICAL PROPERTIES:** noncombustible solid; high resistances to acids, alkalies, and heat; no incompatibilities and reactivities reported; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** none

**HEALTH SYMPTOMS:** inhalation (scarring of the lungs, shortness of breath, cough, heart failure, decreased pulmonary function, pneumoconiosis, acute or chronic bronchitis); contact (enlargement of the ends of the fingers, digital clubbing, eye irritation and/or serous eye damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** human-skin 300µg/3D intermittent; toxic effect: mild irritant effects.

**ACUTE HEALTH RISKS:** cough; sneezing; dyspnea (shortness of breath); vomiting; obstruction of small airways; drying of mucous membranes; respiratory distress; acute bronchitis.

**CHRONIC HEALTH RISKS:** fibrotic pneumoconiosis; cor pulmonale; digital clubbing; lung function abnormalities; chest x-ray pictures with varying degrees of wide-spread nodulation, usually with thickened pleura; impairment of ventilatory function and diffusing capacity; emphysema; pleural sclerosis and fibrosis at site of lung parenchyma and lymph nodes; conglomerate pulmonary lesions; chronic bronchitis; cyanosis; may increase the risk for ovarian cancer in women; death may occur within a few years of a very heavy exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 mg(total dust)/m<sup>3</sup>; ACGIH TLV TWA 3 mg(respirable dust)/m<sup>3</sup>; ACGIH TLV TWA 6 mg(inhalable dust)/m<sup>3</sup>; OSHA PEL TWA 20 mppcf (respirable dust); NIOSH REL TWA 6mg(total dust)/m<sup>3</sup>; NIOSH REL TWA 3 mg(respirable dust)/m<sup>3</sup>; IDLH 3000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing (suits, gloves, footwear, headgear, etc.); wear dust-proof goggles when working with powders or dust; wear appropriate self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill; collect powdered material in a cautious manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; a high efficiency particulate air (HEPA) filter should be used when vacuuming.

**DISPOSAL AND STORAGE METHODS:** collect spilled material and dispose of in a secured sanitary landfill; store in tightly closed containers in a cool, well-ventilated area.

**REGULATORY INFORMATION:** A3.

**OTHER COMMENTS:** used in the manufacture of acid-proof coverings in floors, tables, sinks, etc.; used in switchboard panels of high electrical resistance; sue in crayons for marking cloth, metal, and glass; has also been used in ceramics, cosmetics, pharmaceuticals, putty, plaster, oilcloth, and as a filler in paints.

**KEY REFERENCES:** 4; 5; 7; 15; 16.

### **SOAPSTONE, RESPIRABLE DUST (3MgO-4SiO<sub>2</sub>-H<sub>2</sub>O, 379.3)**

**CAS/DOT IDENTIFICATION #:** none/none

**SYNONYMS:** massive talc, silicates: soapstone (ACGIH:OSHA), soapstone silicate, steatite.

**PHYSICAL PROPERTIES :** white to grayish-white powder; greasy, slippery solid; odorless; insoluble in water, cold acids or in alkalis; unctuous (e.g., oily or greasy), and adheres readily to the skin; may be harder when impure; MP (NA); BP (NA); DN (2.7-2.8 g/cm<sup>3</sup>); SG (2.7-2.8); VD (NA); VP (0 mmHg approximately); MOHS HARDNESS (1-1.5).

**CHEMICAL PROPERTIES:** noncombustible solid; high resistances to acids, alkalis, and heat; no incompatibilities and reactivities reported; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** none

**HEALTH SYMPTOMS:** inhalation (scarring of the lungs, shortness of breath, cough, heart failure, decreased pulmonary function, pneumoconiosis, acute or chronic bronchitis); contact (enlargement of the ends of the fingers, digital clubbing, eye irritation and/or serous eye damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** human-skin 300µg/3D intermittent; toxic effect: mild irritant effects.

**ACUTE HEALTH RISKS:** cough; sneezing; dyspnea (shortness of breath); vomiting; obstruction of small airways; drying of mucous membranes; respiratory distress; acute bronchitis.

**CHRONIC HEALTH RISKS:** fibrotic pneumoconiosis; cor pulmonale; digital clubbing; lung function abnormalities; chest x-ray pictures with varying degrees of wide-spread nodulation, usually with thickened pleura; impairment of ventilatory function and diffusing capacity; emphysema; pleural sclerosis and fibrosis at site of lung parenchyma and lymph nodes; conglomerate pulmonary lesions; chronic bronchitis; cyanosis; may increase the risk for ovarian cancer in women; death may occur within a few years of a very heavy exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 mg(total dust)/m<sup>3</sup>; ACGIH TLV TWA 3 mg(respirable dust)/m<sup>3</sup>; ACGIH TLV TWA 6 mg(inhalable dust)/m<sup>3</sup>; OSHA PEL TWA 20 mppcf (respirable dust); NIOSH REL TWA 6mg(total dust)/m<sup>3</sup>; NIOSH REL TWA 3 mg(respirable dust)/m<sup>3</sup>; IDLH 3000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing (suits, gloves, footwear, headgear, etc.); wear dust-proof goggles when working with powders or dust; wear appropriate self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill; collect powdered material in a cautious manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; a high efficiency particulate air (HEPA) filter should be used when vacuuming.

**DISPOSAL AND STORAGE METHODS:** collect spilled material and dispose of in a secured sanitary landfill; store in tightly closed containers in a cool, well-ventilated area.

**REGULATORY INFORMATION:** A3.

**OTHER COMMENTS:** used in the manufacture of acid-proof coverings in floors, tables, sinks, etc.; used in switchboard panels of high electrical resistance; used in crayons for marking cloth, metal, and glass; has also been used in ceramics, cosmetics, pharmaceuticals, putty, plaster, oilcloth, and as a filler in paints.

**KEY REFERENCES:** 4; 5; 7; 15; 16.

### TALC, CONTAINING ASBESTOS ( $Mg_3(H_2SiO_2)_4$ , 96.33)

**CAS/DOT IDENTIFICATION #:** NA/none

**SYNONYMS:** agalite, asbestine, hydrous magnesium silicate, silicate, talc, containing no asbestos (OSHA), steatite talc, steawhite, talc (ACGIH), talcum.

**PHYSICAL PROPERTIES :** white to grayish white, very fine crystalline powder; odorless; insoluble in water, cold acids or in alkalis; luster pearly or greasy; adheres readily to the skin; may be harder when impure; MP (900-1000°C, 1652-1832°F); BP (unknown); DN (2.7-2.8 g/cm<sup>3</sup>); SG (2.70-2.80); VP (0 mmHg approximately); MOHS HARDNESS (1-1.5).

**CHEMICAL PROPERTIES:** noncombustible solid; high resistances to acids, alkalis, and heat; non-adsorbent to materials in solution; chemically inert medium for filtering any liquid; ultra fine grinds are non-reactive with sensitive toxicants; FP (NA); LFL/UFL (NA); AT (NA); HF (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating (NA); talc itself does not burn; no incompatibilities reported; extinguish fire using an agent suitable for fire-fighting purposes; employees must be trained and equipped as stated in OSHA 190.156, if they are expected to fight fires.

**HEALTH SYMPTOMS:** inhalation (cough, sneezing, dyspnea, tachypnea, vomiting, cyanosis, respiratory acidosis, bronchitis, bronchiolitis, pulmonary edema, emphysema, severe bronchiolar obstruction); skin contact (adhesions, foreign body granulomas); ingestion (fever, vomiting, painful abdomen, presence of talc may be confirmed in the paracentesis fluid).

**FIRST AID:** wash eyes immediately with large amounts of water; wash contaminated skin with soap and water; after breathing large amount of this chemical, get plenty of fresh air immediately; other measures are usually not necessary.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** cough; dyspnea; tachypnea; sneezing; vomiting; cyanosis; pulmonary edema; tachycardia; cardiorespiratory arrest; severe respiratory distress; bronchitis; severe bronchiolar obstruction; chest x-ray may show symmetrical hilar and perihilar alveolar infiltrates which are largely reversible; acute pneumonitis; retinal hemorrhage; reduced vision indicates that considerable lung damage may have already occurred; gastrointestinal effects; topical application to open wounds produces adhesions and foreign body granulomas.

**CHRONIC HEALTH RISKS:** produces talcosis due to talc, silica and asbestos (talc pneumoconiosis); productive cough; dyspnea; rales; diminished breath sounds; limited chest expansion; interstitial fibrosis; granulomas; chronic talc inhalation may increase the risk of bronchogenic carcinoma; pneumoconiosis associated with obstructive and restrictive lung disease has been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $> 2 \text{ mg/m}^3$ , respirable dust (classifiable as a human carcinogen); OSHA PEL: No specific value listed for Talc (containing asbestos) in 29 CFR 1910.1000, Table Z-1. Specifics on this standard can be located in 29CFR1910.1001 (Asbestos); NIOSH REL TWA  $2\text{mg/m}^3$ , respirable fraction; IDLH  $1000 \text{ mg/m}^3$ .

**PERSONAL PROTECTION:** wear protective clothing, including suits, footwear, head-gear and protective gloves; wear dust-proof goggles when working with powders or dust; use an appropriate respirator where the potential exists for exposures over  $2\text{mg/m}^3$ ; where the potential for high exposures exists, use self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** collect powdered material in a convenient and safe manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; do not dry sweep.

**DISPOSAL AND STORAGE METHODS:** collect spilled material using a vacuum or wet method and dispose of in a secured sanitary landfill; store in a cool, well-ventilated area; storage should be in tightly closed containers.

**REGULATORY INFORMATION:** A3; CAL.

**OTHER COMMENTS:** cosmetic grade talc contains more than 90% mineral talc and is free of detectable asbestos; body, baby, face and after-shave powders are usually more than 50%; industrial talc dusts (commercial talcs) have a varied mineral composition and may contain little or no talc; found periodically as a contaminant of starch on surgical gloves.

**KEY REFERENCES:** 3; 4; 5; 7; 15; 16.

### **TALC, CONTAINING NO ASBESTOS ( $\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$ , 96.33)**

**CAS/DOT IDENTIFICATION #:** 14807-96-6/none

**SYNONYMS:** agalite, asbestine, hydrous magnesium silicate, silicate: talc, containing no asbestos (OSHA), steatite talc, steawhite, talc (ACGIH), talcum.

**PHYSICAL PROPERTIES :** white to grayish white, very fine crystalline powder; odorless; insoluble in water, cold acids or in alkalis; luster pearly or greasy; adheres readily to the skin; may be harder when impure; MP ( $900\text{-}1000^\circ\text{C}$ ,  $1652\text{-}1832^\circ\text{F}$ ); BP (unknown); DN ( $2.7\text{-}2.8 \text{ g/cm}^3$ ); SG ( $2.70\text{-}2.80$ ); VP (0 mmHg approximately); MOHS HARDNESS (1-1.5).

**CHEMICAL PROPERTIES:** noncombustible solid; high resistances to acids, alkalis, and heat; non-adsorbent to materials in solution; chemically inert medium for filtering any liquid; ultra fine grinds are non-reactive with sensitive toxicants; FP (NA); LFL/UFL (NA); AT (NA); HF (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating (NA); talc itself does not burn; no incompatibilities reported; extinguish fire using an agent suitable for fire-

fighting purposes; employees must be trained and equipped as stated in OSHA 190.156, if they are expected to fight fires.

**HEALTH SYMPTOMS:** inhalation (cough, rhinitis, dyspnea, vomiting, cumulative lung damage); eye contact (induces granulomas in and about the eye, conjunctival inflammation); skin contact (can induce severe granulomatous reaction when introduced into wounds).

**FIRST AID:** wash eyes immediately with large amounts of water; wash contaminated skin with soap and water; after breathing large amount of this chemical, get plenty of fresh air immediately; other measures are usually not necessary.

**HUMAN TOXICITY DATA:** skin-human 300 $\mu$ g/3D intermittent; reaction: mild.

**ACUTE HEALTH RISKS:** cough; difficult breathing; sneezing; rhinitis; chest pain; weakness; and cyanosis; drying of mucous membranes; obstruction of small airways; irritation of eyes; may cause a reaction in the eyes leading to serious eye damage.

**CHRONIC HEALTH RISKS:** scarring of the lungs; abnormal chest x-ray; shortness of breath; cough; possible disability; talc-induced pneumoconiosis may lead to emphysema and right heart disease; death.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2mg(respirable dust)/m<sup>3</sup>; OSHA PEL TWA 20 mppcf (million particles per cubic foot); NIOSH REL TWA 2 mg(respirable function)/m<sup>3</sup>; IDLH 1000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear protective clothing, including suits, footwear, head-gear and protective gloves; wear dust-proof goggles when working with powders or dust; use an appropriate respirator where the potential exists for exposures over 2mg/m<sup>3</sup>; where the potential for high exposures exists, use self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** collect powdered material in a convenient and safe manner and deposit in sealed containers; use a vacuum or a wet method to reduce dust during clean-up; do not dry sweep.

**DISPOSAL AND STORAGE METHODS:** collect spilled material using a vacuum or wet method and dispose of in a secured sanitary landfill; store in a cool, well-ventilated area; storage should be in tightly closed containers.

**REGULATORY INFORMATION:** A1; A3; CAL.

**OTHER COMMENTS:** used as an additive to clay in ceramic manufacturing and paper coatings; used as a filler in paints, putty, plaster, oilcloth, slate pencils, and crayons; formerly used in dusting powder, either alone or with starch or boric acid; also used as a pigment in paints, varnishes, and rubber; a filler for paper, rubber, and soap; useful as a glove and shoe powder; has also been used as an electric and heat insulator.

**KEY REFERENCES:** 3; 4; 5; 7; 15; 16.

## TREMOLITE, ASBESTIFORM (Ca<sub>2</sub>Mg<sub>5</sub>Si<sub>8</sub>(OH)<sub>2</sub>, 460.38)

**CAS/DOT IDENTIFICATION #:** none/NA2212

**SYNONYMS:** asbestos, fibrous tremolite, tremolite, tremolite asbestos.

**PHYSICAL PROPERTIES:** white to pale green, rigid fibers; has the appearance and properties of glass, i.e., a hard, amorphous, brittle structure; odorless solid; insoluble in water; MP (1316°C, 2400.8°F); BP (NA); DN/SG (2.9-3.2); VP (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; stable at all temperatures up to fusion point (1316°C, 2400.8°F); hazardous polymerization will not occur; resistant to acids; no incompatibilities and/or reactivities have been reported; no hazardous decomposition products have been reported; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; NFPA rating (not rated); not expected to be a fire hazard; not expected to be an explosion hazard; no unusual fire and explosion hazards have been specified in literature; in case of fire in the surroundings, use media appropriate for surrounding material in fire situation; avoid media and procedures that cause airborne dust.

**HEALTH SYMPTOMS:** inhalation (irritates respiratory tract, difficulty in breathing, restricts pulmonary function, chest pains, chest tightness, weakness); contact (interstitial fibrosis, finger clubbing, irritates eyes, asbestos "corns").

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; refer immediately to an ophthalmologist to determine possibility of damage to cornea by fibers; remove asbestos slivers promptly from affected areas of skin; if breathing is difficult, provide oxygen; provide artificial respiration if breathing has stopped; in case of ingestion, seek medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to respiratory tract; can overwhelm normal respiratory defense mechanisms and result in temporary difficulty in breathing; asbestos splinters may penetrate skin and cause asbestos "corns".

**CHRONIC HEALTH RISKS:** labored breathing, chest pains, weakness, and chest tightness are usually manifested 15 - 20 years after exposure; over exposure has caused damage to lungs (asbestosis), lung cancer, and mesothelioma of pleura; asbestos tremolite is listed as a human lung carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 fibers/cm<sup>3</sup>, confirmed human carcinogen; OSHA PEL TWA 0.1 fiber/cm<sup>3</sup> over 5µm in length; NIOSH REL TWA 0.1 fiber/cm<sup>3</sup> over 5µm in length, potential occupational carcinogen; IDLH (not determined), potential occupational carcinogen.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron, sleeves, or body-covering coveralls; wear dust-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; provide capture filtration to remove asbestos particulates from workplace and minimize dispersion; appropriate respirators are needed in areas where the potential exists for asbestos exposure in excess of the permissible exposure level (PEL); wear a half-mask, air-purifying respirator with high-efficiency filters where the potential exists for exposures up to 10 times the permissible exposure level (PEL); up to 50 times the permissible exposure level (PEL), use full-facepiece air-purifying respirator or positive pressure self-contained breathing apparatus; maintain eye-wash baths and safety showers in work area.

**SPILL CLEAN-UP:** notify safety personnel of spill; only trained clean-up personnel should be permitted in spill area; use wet methods and/or approved vacuum cleaning system to pick up spilled materials; use water and/or other dust suppressants where sweeping is unavoidable; avoid breathing dust during clean-up procedures.

**DISPOSAL AND STORAGE METHODS:** dispose of bags, crisp asbestos, waste and scrap material in a manner which will avoid airborne concentrations of asbestos, such as use of dust-tight trash bags and containers; store asbestos in closed containers (dust tight), in clean, dry, secure area; protect containers from physical damage.

**REGULATORY INFORMATION:** T120-c6; A3; A4; CAL; DOT hazard class/division (9); label (class 9).

**OTHER COMMENTS:** Tremolite is a variety of asbestos, Tremolite is sometimes sold as "fibrous talc." As is asbestos, it is used in many acid-resisting applications, and in the manufacture of paints and ceramics.

**KEY REFERENCES:** 4; 5; 6; 7; 11; 14.

## **SILICON (Si, 28.09)**

**CAS/DOT IDENTIFICATION #:** 7440-21-3/UN1346

**SYNONYMS:** defoamer S-10, elemental silicon, silicon powder, amorphous.

**PHYSICAL PROPERTIES:** black to steel-gray, lustrous crystals or black-brown amorphous powder; dark-colored crystals are of the octahedral form, in which the atoms have a diamond arrangement; practically insoluble in water, nitric acid, and hydrochloric acid; soluble in hydrofluoric acid or in a mixture of nitric and hydrofluoric acids; also soluble in molten alkali oxides; MP (1410°C, 2570°F); BP (2355°C, 4271°F); DN (2.33 g/cm<sup>3</sup> at 25°C); SG (2.33); CP (20.0 J/K-mol crystal at 25°C); VD (NA); VP (approximately 0 mmHg at 20°C, 1 mmHg at 1724°C); MOHS HARDNESS (7.0).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; can form more compounds than any other element except carbon; combines with oxygen to form tetrahedral molecules in which one silicon atom is surrounded by four oxygen atoms; able to form silicon-silicon double bonds and silicon-containing organic compounds; can react with fluorine at room temperature, chlorine at 3°C (37°F), nitrogen at 14°C (57°F), sulfur at 6°C (43°F), and phosphorus at 10°C (50°F); bulk form will not react with oxygen, water, and hydrogen halides (except hydrogen fluoride); FP (NA); LFL/UFL (NA); AT (NA); HC (data not available); HF (0.0 kJ/mol crystal at 25°C, 450 kJ/mol gas at 25°C); H<sub>f</sub> (50.21 kJ/mol at 1687K); DIELECTRIC CONSTANT (13); ELECTRON MOBILITY (1500 cm<sup>2</sup>/volt-sec at 300K); HOLE MOBILITY (500 cm<sup>2</sup>/volt-sec at 300K); INTRINSIC CHARGE DENSITY (1.5 X 10<sup>10</sup> at 300K); CONVALENT BOND IONIZATION ENERGY (1.2 eV at 0K); BAND ENERGY GAP 1.106 eV).

**EXPLOSION and FIRE CONCERNS:** combustible solid in powder form; flammable when exposed to flame or by chemical reaction with oxidizers; NFPA rating (not available); reacts violently with alkali carbonates, oxidants, calcium, cesium carbide, cobalt difluoride, iodine pentafluoride, manganese trifluoride, nitrosyl fluoride, silver fluoride, and sodium-potassium alloys; burns in fluorine and chlorine; will react with water or steam to produce hydrogen when heated; in case of fire, all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation(cough, sore throat, irritates eyes, skin, and respiratory tract); eye contact (redness, pain).

**FIRST AID:** wash eyes immediately with plenty of water for several minutes; wash affected areas of skin gently with non-abrasive soap; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, rinse mouth, give plenty of water to drink, and seek medical attention.

**HUMAN TOXICITY DATA:** no LD50/LC50 information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory tract; cough, sore throat.

**CHRONIC HEALTH RISKS:** no information found concerning long-term or repeated exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg (total dust)/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including chemical-resistant gloves, apron or disposable coveralls; wear dust-proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations; for extra personal protection, use a P1 filter respirator for inert particles.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; carefully collect remaining material, then remove to a safe place.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substance into sealable containers and place in a secured, sanitary landfill; store in a cool, dry area; use only with adequate ventilation; separate from oxidizers, halogens (such as chlorine and fluorine), cesium carbide, and alkaline carbonates.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (4.1); label (flammable solid).

**OTHER COMMENTS:** Silicon is the second most abundant element on earth, and constitutes about 25% of the earth's crust; does not occur freely in nature, but is found as silica (e.g., sand, quartz, sandstone) or as various silicates (e.g., kaolinite, anorthite, etc.); used as a semiconductor in transistors, computer circuitry, rectifiers, etc.; used for making alloys such as steel, aluminum, copper, bronze, and iron; utilized in the manufacture of silanes and silicones; has also been used as a reducing agent in high temperature reactions.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **SILICON CARBIDE (SiC, 40.10)**

**CAS/DOT IDENTIFICATION #:** 409-21-2/none

**SYNONYMS:** carbon silicide, carborundum<sup>®</sup>, silicon monocarbide.

## 900 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**PHYSICAL PROPERTIES:** yellow to green to bluish-black, iridescent, sharp crystals; colorless when pure; hexagonal or cubic structure; extremely hard; soluble in fused potassium hydroxide and molten iron; insoluble in water, alcohol, and acids; MP (2700°C, 4892°F) (sublimes); BP (> 2000°C, >3632°F); DN (3.217 g/cm<sup>3</sup>); SG (3.2); CP (26.9 J/K-mol crystal at 25°C (cubic), 26.7 J/K-mol crystal at 25°C (hexagonal)); VD (NA); VP (approximately 0 mmHg at 20°C); MOHS HARDNESS (9.5).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; sublimes at melting point with decomposition; able to resist oxidation at high temperatures; excellent thermal conductivity; electrically conductive; no incompatibilities or reactivities reported; FP (NA); LFL/UFL (NA); AT (NA); DIELECTRIC CONSTANT (7.0); ELECTRON MOBILITY (>100 cm<sup>2</sup>/volt-sec); HOLE MOBILITY (>20 cm<sup>2</sup>/volt-sec); BAND ENERGY GAP (2.8 eV).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; not expected to be a fire hazard; not expected to be an explosion hazard; NFPA rating (not available); substance decomposes on heating to 2700°C (4892°F); in case of fire in the surroundings, all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation(cough, sore throat, irritates eyes, skin, and respiratory tract); eye contact (redness, pain).

**FIRST AID:** wash eyes immediately with plenty of water for several minutes; wash affected areas of skin gently with non-abrasive soap; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped; in case of ingestion, rinse mouth, give plenty of water to drink, and seek medical attention.

**HUMAN TOXICITY DATA:** no LD50/LC50 information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and upper respiratory tract; cough, sore throat.

**CHRONIC HEALTH RISKS:** no information found concerning long-term or repeated exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg (total dust)/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including chemical-resistant gloves, apron or disposable coveralls; wear dust-proof safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations; for extra personal protection, use a P1 filter respirator for inert particles.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; carefully collect remaining material, then remove to a safe place.

**DISPOSAL AND STORAGE METHODS:** sweep spilled substance into sealable containers and place in a secured, sanitary landfill; store in a cool, dry area; use only with adequate ventilation.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none); label (none).

**OTHER COMMENTS:** used as an abrasive for cutting and grinding metals; used in polishing glass and granite; utilized in the manufacture of porcelain, shoe soles, refractor brick, emery paper, and furnace linings; used in anti-skid pavements; useful in semiconductor technology.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

**SILVER, METAL AND SOLUBLE COMPOUNDS** (Soluble silver compounds have variable molecular formulas and variable formula weights. The molecular formula for silver is Ag. The formula weight for silver is 107.87.)

**CAS/DOT IDENTIFICATION #:** Soluble silver compounds have variable CAS #s. The CAS # for silver is 7440-22-4. There is no DOT identification number listed for silver metal in the literature.

**SYNONYMS:** Synonyms vary depending upon the specific soluble silver compound. The synonyms for silver are as follows: argentum, shell silver, silver atom, silver metal.

**PHYSICAL PROPERTIES:** appearance and odor vary depending upon the specific soluble silver compound. Physical properties of silver metal and two specific soluble silver compounds are provided for illustrative purposes; (silver) white, lustrous solid; soft malleable, and ductile; face-centered cubic structure; soluble in fused alkali hydroxides in presence of air, in fused alkali peroxides, and in alkali; not soluble in hot or cold water; MP (960.5°C, 1761°F); BP (approximately 2000°C, 3632°F); DN (10.50 g/cm<sup>3</sup> at 20°C); SG (10.49); CP (25.4 J/K-mol crystal at 25°C); VD (not applicable); VP (negligible at 20°C); (silver nitrate) colorless, transparent, large rhombic crystals becoming gray or grayish-black on exposure to light in the presence of organic matter; odorless; bitter, metallic taste; soluble in cold water, but more soluble in hot water; readily soluble in ammonia, glycerol, and hot alcohol; slightly soluble in ether; MP (212°C, 413.6°F); BP (444°C, 831°F at 760 mmHg) (decomposes); DN (4.352 g/cm<sup>3</sup> at 19°C); SG (4.4 at 20°C); CP (93.1 J/K-mol crystal at 25°C); VD (not applicable); VP (negligible at 20°C); (silver fluoride) yellow or brownish crystalline mass; becomes dark on exposure to light; soluble in water; soluble in hydrogen fluoride, ammonia, and methyl cyanide; MP (435°C, 815°F); BP (1159°C, 2118°F at 760 mmHg) (decomposes); DN (5.852 g/cm<sup>3</sup> at 15.5°C); SG (5.8); VD (not applicable); VP (negligible at 20°C).

**CHEMICAL PROPERTIES:** Properties vary depending upon the specific soluble silver compound. Chemical properties of silver metal and two specific soluble silver compounds are provided for illustrative purposes; (silver) stable in air and water; tarnishes in air containing sulfur, with formation of black sulfide; excellent conductor of heat and electricity; blackened by exposure to ozone and hydrogen sulfide; excellent light reflector that resists oxidation; reacts readily with dilute nitric acid and hot concentrated sulfuric acid; strongly absorbs oxygen at the melting point; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); H<sub>f</sub> (11.3 kJ/mol at 1234.93 K); (silver nitrate) light-sensitive when trace amounts of organic chemical are present; not photosensitive when pure; reduced by hydrogen sulfide in the dark; forms a yellowish liquid at the melting point, which then solidifies to a white, crystalline mass on cooling; decomposes at 440°C (824°F) into metallic silver, oxygen, nitrogen, and oxides of nitrogen; aqueous solutions are neutral to litmus; (silver fluoride) very hygroscopic; gradually becomes insoluble in moist air due to basic fluoride formation; forms several hydrates; cooling a solution of silver fluoride (AgF) in hydrogen fluoride (HF), will yield an acid fluoride; aqueous solutions are considered neutral; silver oxide renders aqueous solutions of silver fluoride alkaline; heating to decomposition emits toxic fumes of fluorides.

## 902 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**EXPLOSION and FIRE CONCERNS:** metallic silver is a noncombustible solid, but flammable in form of dust and powder; most soluble silver compounds are not combustible; contact of metallic silver and soluble silver compounds with acetylene may cause formation of silver acetylide that is sensitive to shock; formation of compounds that are explosive when dry will result upon contact with ammonia; contact with strong hydrogen peroxide solutions will cause violent decomposition to oxygen gas; silver nitrate is a strong oxidizing agent, capable of increasing the flammability of combustible or organic materials; soluble silver compounds will attack some forms of plastics, rubber, and coatings, the following soluble silver compounds are explosives: silver acetylide, silver fulminate, silver tetrazene, silver tartarate mixtures, silver azide, silver styphnate, and silver oxalate mixtures; decomposition of some soluble silver compounds will emit toxic gases and vapors (such as oxides of nitrogen).

**HEALTH SYMPTOMS:** inhalation (nausea, vomiting, dizziness, difficult breathing, irritates eyes, skin and respiratory system); contact (severe eye and skin burns).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush contaminated skin with plenty of water; if breathing is difficult, provide oxygen; begin rescue breathing if breathing has stopped; in case of ingestion, give large quantities of water immediately and induce vomiting; seek prompt medical attention.

**HUMAN TOXICITY DATA:** inhalation-human  $TCLo$  1 mg/m<sup>3</sup>; toxic effect: skin.

**ACUTE HEALTH RISKS:** irritation to the skin and mucous membranes; may cause abdominal pain and gastroenteritis; pulmonary edema; hemorrhage; may cause death if ingested.

**CHRONIC HEALTH RISKS:** the dust of silver and its soluble compounds cause argyria, the build-up of deposited silver in tissues, leading to gray-blue discoloration of eyes, skin, nasal septum, and throat; may cause mild, chronic bronchitis; necrosis of bone marrow, liver, and kidney may occur.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg (metal)/m<sup>3</sup>, 0.01 mg (soluble compounds, as Ag)/m<sup>3</sup>; OSHA PEL TWA 0.01 mg/m<sup>3</sup> (silver, metal and soluble compounds); NIOSH REL TWA 0.01 mg/m<sup>3</sup> (silver, metal and soluble compounds); IDLH 10 mg (as Ag)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use dust-and-splash-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; cautiously collect spilled material and deposit in sealed containers for proper disposal; liquid containing silver metal or soluble silver compounds should be absorbed with noncombustible materials (such as dry earth, sand, or vermiculite).

**DISPOSAL AND STORAGE METHODS:** silver metal and soluble silver compounds may be disposed of in sealed containers in a secured, sanitary landfill, metallic silver may be routed to a metal salvage facility; store in a cool, dry location; maintain adequate ventilation; keep in the dark, as most silver salts are light-sensitive; separate from combustibles, such as acetylene, ammonia, hydrogen peroxide, and chlorine trifluoride.

**REGULATORY INFORMATION:** A1; Reportable Quantity (RQ): 1000 lbs (454 kg); DOT classification (no information found in literature).

**OTHER COMMENTS:** silver metal and soluble silver compounds have applications in the following list of common operations: used in the manufacture of silver nitrate for use in photography, mirrors, inks, dyes, and porcelain; used in the manufacture of silver salts as catalysts in oxidation-reduction and polymerization reactions; also utilized in chemical synthesis, in glass manufacture, in silver-plating, in photography, as laboratory reagents, and in medicine.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12;16.

### **SODIUM FLUOROACETATE (CH<sub>2</sub>FCOONa, 100.03)**

**CAS/DOT IDENTIFICATION #:** 62-74-8/UN2629

**SYNONYMS:** fluoroacetic acid sodium salt, furatol, sfa, sodium fluoroacetic acid, sodium monofluoroacetate.

**PHYSICAL PROPERTIES :** fluffy colorless to white powder; odorless, hygroscopic solid; sometimes dyed black; exists as a liquid above 95°F (35°C); good solubility in water; sparingly soluble in methanol and ethanol; practically insoluble in acetone and carbon tetrachloride; MP (200°C, 392°F); BP (decomposes below melting point at 200°C); DN (unknown, but >1); SG (>1); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; non-volatile; decomposes at 200°C; no incompatibilities and reactivities reported; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** not combustible; not considered to be a fire hazard; not considered to be an explosion hazard; decomposes on heating or on burning producing toxic gases and vapors, such as hydrogen fluoride and carbon monoxide; in case of fire in the surroundings, use dry chemical, carbon dioxide, water spray, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (convulsions, labored breathing, unconsciousness); skin absorption (numbness of face, facial twitching, apprehension, tingling of the nose and face, auditory hallucinations, epileptic form convulsions); ingestion (vomiting, ventricular contractions, irregular heartbeat, hemorrhagic pulmonary edema, degenerates renal tubules, effects on central nervous system).

**FIRST AID:** flush eyes immediately with plenty of water for several minutes; wash affected areas of skin with plenty of water or shower; if breathing is difficult, provide oxygen; if breathing has stopped, provide artificial respiration; in case of ingestion, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** oral-human LDLo 714µg/kg; unreported-man LDLo 5mg/kg.

**ACUTE HEALTH RISKS:** convulsions; labored breathing; vomiting; apprehension; auditory hallucinations; tingling sensations of the nose and face; facial numbness; twitching; pulsus alternans; ectopic heartbeats; tachycardia; ventricular fibrillation; respiratory failure; hemorrhagic pulmonary edema; degeneration of renal tubules; unconsciousness; may result in death.

**CHRONIC HEALTH RISKS:** kidney damage has been observed in humans; liver damage; causes cardiac arrhythmias; experimental reproductive effects have been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.05 mg/m<sup>3</sup> (skin); OSHA PEL TWA 0.05 mg/m<sup>3</sup> (skin); NIOSH REL TWA 0.05 mg/m<sup>3</sup>; NIOSH REL STEL 0.15 mg/m<sup>3</sup> (skin); IDLH 2.5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; use chemical safety goggles or face shield; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; wear self-contained breathing apparatus for extra personal protection; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; sweep spilled substance into sealable containers; moisten first to prevent dusting; if in liquid form, absorb with noncombustible materials (e.g., dry earth, sand, vermiculite), and place in chemical waste containers.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in sealable containers in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry location; use only with adequate ventilation; keep in well closed containers; separate from food and feedstuffs.

**REGULATORY INFORMATION:** F1; Sf2; Sf3; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used mainly as an immediate action rodenticide; use in the formulation of pesticides used for the elimination of predators.

**KEY REFERENCES:** 4; 5; 6; 7; 11; 14; 16.

### **SODIUM HYDROXIDE (NaOH, 40.0)**

**CAS/DOT IDENTIFICATION #:** 1310-73-2/UN1823 (solid), UN1824 (solution).

**SYNONYMS:** caustic soda, lye, soda lye, sodium hydrate, white caustic.

**PHYSICAL PROPERTIES :** white pellets, flakes, sticks, or deliquescent, orthorhombic powder; may be shipped as water solution; odorless; soluble in water, alcohol, and glycerol; very soluble in water; insoluble in diethyl ether and acetone; MP (318°C, 604°F); BP (1390°C, 2534°F); DN (2.120 g/cm<sup>3</sup> at 20°C); SG (2.13 at 25°C); VD (NA); VP (0 mmHg at 20°C, 1 mmHg at 739°C).

**CHEMICAL PROPERTIES:** strong alkali; very caustic to animal and vegetable tissue; corrosive to aluminum metal in the presence of moisture; rapidly absorbs carbon dioxide and water from air; undergoes polymorphic transition at 2°C; readily reacts with atmospheric carbon dioxide forming sodium carbonate; dissolves in water, releasing significant heat; generates considerable heat when the solution is mixed with an acid; can react with metals, such as aluminum, tin, and zinc; reacts with formaldehyde hydroxide to yield formic acid and hydrogen; FP (NA); LFL/UFL(NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid, but contact with water may release heat sufficient to ignite combustible materials; NFPA rating Health 3, Flammability 0, Reactivity 1; can ignite or react violently with acetic acid, acetaldehyde, acetic anhydride, acrolein, acrylonitrile, allyl chloride, aluminum, chlorine trifluoride, chloroform and methanol, chlorohydrin, chlorosulfonic acid, 1,2-dichloroethylene, glyoxal, hydrogen chloride, hydrogen fluoride, hydroquinone, nitric acid, sulfuric acid, nitroethane, nitropropane, nitromethane, tetrahydrofuran, water, zinc, and others; reacts to form explosive products with ammonia and silver

nitrate, cyanogen azide, and glycols above 230°C; forms the poisonous gas arsine when mixed with aluminum and arsenic compounds; vigorous reaction with 1,2,4,5-tetrachlorobenzene has caused many industrial explosions; reacts explosively with bromine, nitrobenzene and heat, sodium tetrahydroborate, and zirconium and heat; dangerous material to handle; heating to decomposition yields toxic fumes of sodium oxide; use water or agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (mild irritation of mucous membranes, severe pneumonitis, damage to upper respiratory tract, lung damage); ingestion (serious damage to mucous membranes, perforation and scarring of tissues, vomiting, stomach pain, burns of the mouth, tongue, and pharynx); contact (skin burns with deep ulceration, temporary hair loss).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink large quantities of water immediately to dilute the sodium hydroxide.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; destructive to tissues of mucous membranes; pneumonitis; burns eyes and skin; temporary loss of hair; corneal opacification; edema and ulceration of the cornea; severe stomach pain; severe pain in the esophagus; corrosion of the lips, mouth, tongue, and pharynx; vomiting of large pieces of mucosa; death.

**CHRONIC HEALTH RISKS:** severe skin burns with scarring; possible blindness; scarring of the esophagus; esophageal cancer; lung damage.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 2 mg/m<sup>3</sup>; OSHA PEL TWA2 mg/m<sup>3</sup>; NIOSH REL CL 2 mg/m<sup>3</sup>15M; IDLH 10 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, gloves, and face shields; use dust-and splash-proof safety goggles; wear positive pressure self-contained breathing apparatus; facilities for quick drenching of the body and an eye-wash fountain should be provided within immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; keep water away from release; shovel into suitable dry container; spill may be diluted with water and neutralized with 6 molar hydrochloric acid..

**DISPOSAL AND STORAGE METHODS:** shovel into sealed dry containers and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; separate from acids, water, and metals; prompt cleanup and removal are necessary.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 1000 lbs (454 kg); Sfl; CW1; CW2; A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used in the manufacture of soaps and detergents; used as a saponifying agent, in metal processing and refining; used in petroleum refining for removal of sulfur compounds; used to neutralize acids and make sodium salts; may be used to treat cellulose in making viscose rayon and cellophane; used in reclaiming rubber to dissolve out the fabric; used in food processing to peel fruits and vegetables, process olives, and refine vegetable oils.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 12; 14; 16.

**STARCH ((C<sub>6</sub>H<sub>10</sub>O<sub>5</sub>)<sub>n</sub>, formula weight varies)**

CAS/DOT IDENTIFICATION #: 9005-25-8/none

**SYNONYMS:** ARGO® brand corn starch, corn starch, rice starch, sorghum gum, α-starch, starch gum, tapioca starch.

**PHYSICAL PROPERTIES:** fine, white, amorphous powder or granules; tasteless and odorless; various crystalline forms may be obtained, including microcrystalline; insoluble in water; MP (decomposes); BP (decomposes); DN/SG (1.45); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; irreversible gel formation occurs in hot water; compounds such as formamide, formic acid, strong bases, and metallic salts, can induce swelling of granules at room temperature; can react with oxidizing materials; converts to glucose by water in the presence of suitable catalysts; mixture with dibasic acids, hydrogen-donating compounds, and catalysts dissolved in water, forms a reactive polyol; the slurry may yield a low viscosity polymer in a 50% solids aqueous solution when subjected to high temperatures and pressures; the polymer formed can be further reacted with acids, bases, and crosslinking agents; FP (NA); LFL/UFL (NA); AT(NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; may form explosive mixtures with air; flammable and moderately explosive when exposed to flame; NFPA rating (not rated); contact with strong oxidizers may cause fire and explosion; incompatible with acids, iodine, and strong alkalis; minimum explosive concentration (MEC) is 50 g/m<sup>3</sup>; use extinguishing agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and mucous membranes); contact (dermatitis, discharge of thin nasal mucus); ingestion (coughing, chest pain).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; after breathing in large amounts of this chemical, promptly move exposed person to fresh air; other measures are usually not necessary; if this chemical has been swallowed, seek immediate medical attention.

**HUMAN TOXICITY DATA:** skin-human 300μg/3D intermittent; toxic effect: mild irritation effects.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and mucous membranes; cough; chest pain; rhinorrhea (discharge of thin nasal mucus).

**CHRONIC HEALTH RISKS:** repeated or prolonged skin contact will cause dermatitis; has been reported to be an allergen; targets eyes, skin, and respiratory system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear appropriate personal protective clothing to prevent skin contact; use dust-proof safety goggles; enclose operations and/or provide local exhaust ventilation at the site of chemical release; appropriate respirators are needed in areas where exposures are above the permissible exposure level; in unknown concentrations or IDLH conditions, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; cautiously collect spilled material and deposit in sealed containers for reclamation, or for disposal in a secured, sanitary landfill; liquid containing starch may be absorbed with inert materials, such as dry earth or sand.

**DISPOSAL AND STORAGE METHODS:** starch may be disposed of in sealed containers in a secured, sanitary landfill; storage should be in suitably protected and well-ventilated areas at ambient temperature; avoid heat and open flame; separate from strong oxidizers, acids, and bases.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none).

**OTHER COMMENTS:** starch is a mixture of a water-dispersible fraction called amylose (25%) and a second component, amylopectin (75%); may be used as an adhesive, as a textile filler and sizing agent, and in the manufacture of machine-coated paper; used as gelling agent and thickener in food products (custards, gravies, confectionery), as a filler in baking powders (cornstarch), and as a fabric stiffener in laundering; also used as an anti-caking agent in sugar and face powders; employed as an indicator in analytical chemistry.

**KEY REFERENCES:** 4; 5; 6; 7.

### **STIBINE (SbH<sub>3</sub>, 124.78)**

**CAS/DOT IDENTIFICATION #:** 7803-52-3/UN2676

**SYNONYMS:** antimony hydride, antimony trihydride, hydrogen antimonide.

**PHYSICAL PROPERTIES :** colorless gas; colorless liquid and crystals at liquid air temperature; disagreeable odor like hydrogen sulfide; gas is slightly soluble in water; very soluble in alcohol, carbon disulfide, and other organic solvents; MP (-88°C, -126°F); BP (-17°C, -1°F); DN (2.204 g/mL at -17°C); LSG (2.20); CP (41.1 J/K-mol gas at 25°C); HV (21.3 kJ/mol at 256K); VD (4.36); VP (>760 mmHg at 20°C); OT (NA).

**CHEMICAL PROPERTIES:** thermally unstable; decomposes in air; decomposes above 200°C (392°F); reacts with acids, halogenated hydrocarbons, oxidizers, and moisture; decomposition products are hydrogen and metallic antimony, generally deposited in the form of a mirror; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** flammable gas; NFPA rating Health 4, Flammability 4, Reactivity 2; flashback along vapor trail may occur; reacts explosively with chlorine, concentrated nitric acid, ammonia and heat, and ozone; quickly destroyed at 200°C; closed containers may rupture violently when heated; thermally less stable than arsine; evolves hydrogen and ignites on contact with many materials; incompatible with oxidants; antimony and hydrogen will be released on decomposing; combustion by-products include toxic fumes of antimony; stop flow of gas and then use flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, weakness, nausea, back and abdominal pain, pulmonary irritation, jaundice, destroys red blood cells, damage to the kidneys).

**FIRST AID:** provide oxygen or respiratory support; get immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** headache; weakness; nausea; abdominal pain; lumbar pain; dark red urine; yellow jaundice; lung irritation; death.

**CHRONIC HEALTH RISKS:** allergic respiratory reaction; sensitization; hemoglobinuria; hematuria; hemolytic anemia; kidney damage; liver damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 ppm; OSHA PEL TWA 0.1 ppm (0.5 mg/m<sup>3</sup>); NIOSH REL TWA 0.1 ppm (0.5 mg/m<sup>3</sup>); IDLH 5 ppm.

**PERSONAL PROTECTION:** wear appropriate chemical protective gloves, boots, and goggles; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of leak to disperse gas; remove all sources of ignition; control source of stibine formation.

**DISPOSAL AND STORAGE METHODS:** use water spray to cool and reduce vapors; store in a cool dry location with adequate ventilation; separate from acids, alkalies, halogenated compounds, oxidizing materials, and water; outside storage is preferred.

**REGULATORY INFORMATION:** A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas, flammable gas).

**OTHER COMMENTS:** used as a chemical intermediate and in chemical synthesis; has been used as a fumigating agent; liberated from alloys of antimony compounds which come in contact with reducing agents; liberation from purification of antimony by electrolysis.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 16.

**STODDARD SOLVENT** (generally C<sub>9</sub> through C<sub>11</sub> paraffins (85%) and aromatics (15%), formula weight varies)

**CAS/DOT IDENTIFICATION #:** 8052-41-3/UN1268

**SYNONYMS:** dry cleaning safety solvent, naphtha safety solvent, petroleum solvent, spotting naphtha, varnoline, white spirits.

**PHYSICAL PROPERTIES :** clear, colorless liquid; kerosene-like odor; miscible with alcohol, benzene, ether, chloroform, carbon tetrachloride, carbon disulfide, and some oils; insoluble in water; MP (NA); BP (154-202°C, 309-396°F); DN (1.0 g/mL); LSG (0.78 at 20°C); VD (5.0 at boiling point); VP (2 mmHg (estimate) at 20°C); OT (1 ppm).

**CHEMICAL PROPERTIES:** combustible liquid; heat may contribute to instability; will attack some forms of plastics, rubber, and coatings; can react with oxidizing materials; distillation range is more than 50% over at 177°C (350°F), 90% over at 190°C (375°F), and the end point below 210°C (410°F); FP (37.8-43.3°C, 100-110°F); LFL/UFL (1.1%, 6%); AT 232°C, 450°F).

**EXPLOSION and FIRE CONCERNS:** flammable liquid when exposed to heat, sparks, or flame; NFPA rating (NA); explosive in vapor form when exposed to heat or flame; contact with strong oxidizing agents may cause fires and explosions; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use carbon dioxide, dry chemical, or foam for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, fatigue, narcotic effects, destructive to tissues of mucous membranes, irritates eyes, nose and throat); skin contact (dermatitis, yellow jaundice); ingestion (blood effects, kidney damage, liver injury, chemical pneumonia)

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** eye-human 470 ppm/15M.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; dizziness; chemical pneumonia; loss of consciousness; headache; death.

**CHRONIC HEALTH RISKS:** central nervous system effects; liver damage; kidney damage; defatting of skin, resulting in dermatitis; may affect red and white blood cell count; impaired pulmonary function; fatigue; jaundice; marrow hypoplasia.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100 ppm; OSHA PEL TWA 500 ppm (2900 mg/m<sup>3</sup>); NIOSH REL TWA 350 mg/m<sup>3</sup>; NIOSH REL CL 1800 mg/m<sup>3</sup>/15M; IDLH 20,000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** use impervious clothing including aprons, sleeves and boots; use chemical-resistant gloves; splash-proof safety goggles are recommended; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; large quantities can be collected and atomized in a suitable combustion chamber; absorb as much as possible with materials such as earth or sand; flush remaining stoddard solvent with large amounts of water but not into spaces such as sewers because of danger of explosions; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; atomize large amounts in a suitable combustion chamber; store in a cool, dry location with adequate ventilation; should not be stored near oxidizing agents or combustible materials; outside storage is preferred.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a solvent in dry cleaning industry; used in the manufacture of aerosol sprays as a solvent for paints and varnishes; used in metal cleaning and degreasing; use as a solvent for printing inks and textile-printing industries; useful in the manufacture of sprays for pesticides, herbicides, household cleaners, and silicone compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 16.

### **STRYCHNINE(C<sub>21</sub>H<sub>22</sub>N<sub>2</sub>O<sub>2</sub>, 334.45)**

**CAS/DOT IDENTIFICATION #:** 57-24-9/UN1692

**SYNONYMS:** gopher bait, mole death, mouse-rid, nux vomica, strychnos.

**PHYSICAL PROPERTIES:** colorless to white crystalline solid; orthorhombic prisms; odorless; very bitter metallic taste; soluble in chloroform; slightly soluble in alcohol and benzene; very slightly soluble in ether, petroleum ether and water; MP (268-290°C, 514.4-554°F); BP (270°C, 518°F at 5 mmHg); DN (1.359 g/cm<sup>3</sup> at 18°C); SG (1.36 at 20°C); VP (0 torr at 20°C); OT (6.0 x 10<sup>-4</sup> mg/L water).

**CHEMICAL PROPERTIES:** combustible solid; stable in air; reacts with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HC (2,685.7 kg/cal at 20°C solid).

**EXPLOSION and FIRE CONCERNS:** combustible solid, but difficult to ignite; NFPA rating Health 3, Flammability 0, Reactivity 0; material itself does not burn, or burns with difficulty; dangerous; when heated, emits highly toxic fumes of oxides of nitrogen; incompatible with strong oxidizers; use flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sense of impending suffocation, cyanosis, convulsive movements, restlessness, apprehension, increased acuity of perception); contact (stiff neck and facial muscles, muscular twitching, successive attacks of spasms).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 30mg/kg; oral-man LDLo 30mg/kg; oral-man LDLo 5143 mg/kg.

**ACUTE HEALTH RISKS:** stiff neck and facial muscles; restlessness; feeling of uneasiness; heightened reflex of irritability; apprehension; muscular twitching; sense of impending suffocation; convulsive movements; shrieking sounds; successive attacks of spasms; increasing violent symptoms; cyanosis; death.

**CHRONIC HEALTH RISKS:** chronic allergen; systemic effects are unknown.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.15 mg/m<sup>3</sup>; OSHA PEL TWA 0.15 mg/m<sup>3</sup>; NIOSH REL TWA 0.15mg/m<sup>3</sup>; IDLH 3 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear plastic working clothes; butyl rubber gloves are recommended; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill; collect spilled material and deposit in sealed containers for disposal in a secure sanitary landfill; absorb liquid containing strychnine in non-combustible materials such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** pour onto thick layer of sand-soda ash mixture and burn in incinerator; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers.

**REGULATORY INFORMATION:** F1; R4; R6; R8; Reportable Quantity (RQ): 10 lbs (4.54kg); Sf1; Sf2; CW1; CW2; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used for destroying rodents and predatory animals and for trapping fur-bearing animals; in the past, was widely used for control of all pest animals including rodents; material has been replaced to large extent for field rodent control, although it still plays a significant role in control of porcupines and pocket gophers; most often noted as the poison of choice in malicious destruction of pests.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 11; 12.

## **STYRENE (C<sub>6</sub>H<sub>5</sub>CH=CH<sub>2</sub>, 104.16)**

**CAS/DOT IDENTIFICATION #:** 100-42-5/UN2055

**SYNONYMS:** cinnamene, ethenylbenzene, phenylethene, phenylethylene, styrene monomer, styrol, vinylbenzene.

**PHYSICAL PROPERTIES** : colorless to light yellow, oily liquid; viscous liquid; rubbery; sweet floral odor at low concentrations; extremely penetrating odor at higher concentrations; soluble in carbon disulfide, alcohol, ether, methanol, ethanol, acetone, toluene, carbon tetrachloride, and heptane; soluble in all proportions in benzene and petroleum ether; slightly soluble in water; MP (-31°C, -23°F); BP (145°C, 293°F); DN (0.9074 g/mL at 20°C); LSG (0.91); ST (32.14 dynes/cm at 19°C); VS (0.751 mPa); CP (182.0 J/K-mol liquid at 25°C); HV (86.8 cal/g, 3.63 x 10<sup>5</sup> J/kg); VD (3.6); VP (5 mmHg at 20°C); OT (0.73 ppm in water, 0.32 ppm in air).

**CHEMICAL PROPERTIES**: slowly undergoes polymerization and oxidation with formation of peroxides on exposure to light and air; corrodes copper and copper alloys; usually contains a polymer inhibitor such as tert-butylcatechol; reacts vigorously with oxidizers, peroxides, strong acids, aluminum chloride, and catalysts for vinyl polymers; FP (31°C, 88°F); LFL/UFL (1.1%, 7.0%); AT (490°C, 914°F); HC (4,381 kJ/mol at 20°C); HF (103.8 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS**: flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 2; flashback along vapor trail may occur; vapor may explode if ignited in confined area; closed containers may explode violently when heated; liquid may float on water; travel to ignition source, and spread fire; involved in several industrial explosions; storage hazard above 32°C; very dangerous fire hazard; explosive in vapor form when exposed to heat or flame; heat-sensitive explosive peroxides are formed when reacted with oxygen above 40°C; violent reaction with chlorosulfonic acid, oleum, sulfuric acid, and chlorine and iron (III) chloride above 50°C; hazardous polymerization may be initiated by alkali-metal-graphite composites, dibenzoyl peroxide, di-tert-butyl peroxide, butyllithium, and other initiators; reacts vigorously with strong oxidizers; may ignite when heated with air and polymerizing polystyrene; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (eye and olfactory changes, irritation and violent itching of the eyes, lacrimation, anesthetic or narcotic effect); contact (defatting dermatitis).

**FIRST AID**: wash eyes immediately with large amounts of water; wash skin immediately with large amounts of water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA**: skin-human 500 mg nose; inhalation - human LCLo 10,000ppm/30M; inhalation-human TCLo 600ppm; toxic effect: nose, eye; inhalation-human TCLo 20µg/m<sup>3</sup>; toxic effect: eye.

**ACUTE HEALTH RISKS**: irritation of eyes, nose and respiratory system; drowsiness; weakness; unsteady gait; narcosis; dermatitis; headache; dizziness; nausea; vomiting; gastrointestinal effects; central nervous system depression.

**CHRONIC HEALTH RISKS**: effects on central nervous system; weakness; fatigue; depression; headache; possible liver damage; reproductive effects; peripheral neuropathy; effects on blood; minor effects on kidney enzyme functions; increased risk of leukemia; increased risk of lymphoma; EPA Group C: possible human carcinogen.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 50 ppm; ACGIH TLV STEL 100 ppm (skin); OSHA PEL TWA 100 ppm; OSHA PEL CL 200 ppm; OSHA PEL 600 ppm/5M/3H; NIOSH REL TWA 50 ppm (215 mg/m<sup>3</sup>); NIOSH REL STEL 100 ppm (425 mg/m<sup>3</sup>); IDLH 700 ppm.

## 912 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**PERSONAL PROTECTION:** wear full protective clothing (boots, apron, chemical-resistant gloves, etc.); wear chemical safety goggles; use self-contained breathing apparatus in high vapor concentrations; a full-facepiece is recommended above 400 ppm.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in a fume hood; absorb large quantities in non-combustible material and atomize in a suitable combustion chamber; mixing styrene with a more flammable solvent may also improve combustion; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb in noncombustible material and place in a sanitary landfill; dissolve in a more flammable solvent and atomize in a suitable combustion chamber equipped with afterburner and scrubber; can be burned under control; can blow air through contaminated water and burn exit gases; store in a cool, dry place; separate from oxidizing materials, peroxides, and metal salts; keep containers tightly closed, away from heat, sparks, and open flame.

**REGULATORY INFORMATION:** CA2; S32-47; S50-b17; S61-a14; S62'-14; R2-50; R3; R5; Reportable Quantity (RQ): 1000 lbs (454 kg); Sf1; Sf3; CW1; CW2; A1; A2; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of plastics and synthetic rubber; used as an insulating agent; used in the manufacture of styrenated polyester, rubber-modified polystyrene, and copolymer resins; used as a monomer for straight polystyrene; chemical intermediate for styrenated phenols and styrene oxide; used as a synthetic flavoring substance, e.g. for ice cream and candy; also used to make paints..

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

### SUCROSE (C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>, 342.34)

**CAS/DOT IDENTIFICATION #:** 57-50-1/none

**SYNONYMS:** alpha-d-glucopyranosyl-beta-d-fructofuranoside, beet sugar, can sugar, confectioner's sugar, granulated sugar, rock candy, saccharose, sugar, table sugar.

**PHYSICAL PROPERTIES :** hard, white dry crystals, lumps or powder; odorless; may have a characteristic caramel odor when heated; sweet taste; finely divided sugar is hygroscopic and absorbs up to 1% moisture which is given up on heating to 90°C (194°F); soluble in water; slightly soluble in alcohol; moderately soluble in glycerol and pyridine; insoluble in ether; MP (160-186°C, 320-367°F); BP (decomposes); DN (1.5877 g/cm<sup>3</sup> at 25°C); SG (1.59 at 20°C); VD (no information found); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable in air; stable under ordinary conditions of use and storage; hazardous polymerization will not occur; hydrolyzes to glucose and fructose by dilute acids and by invertase, a yeast enzyme; optical rotation falls and is negative upon completion of hydrolysis; does not reduce Fehling's solution (consists of two solutions, one of copper sulfate, the other of alkaline tartrate), forms an osazone, or show mutarotation; fermentable, but resists bacterial decomposition when in high concentrations. FP (NA); LFL/UFL (NA); AT (NA); MEC (45g/cm<sup>3</sup>).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid, but fine airborne dust may explode; not considered to be a fire hazard; NFPA rating Health 0, Flammability 1, Reactivity 0; fine dust in the presence of an ignition source is a potential dust explosion hazard; minimum explosive concentration in air: 0.045 g/L; reacts vigorously with nitric acid or sulfuric

acid, forming carbon monoxide and carbon dioxide; carbon dioxide and carbon monoxide may form when heated to decomposition; use any means suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract, cough); contact (mechanical irritation of eyes, no adverse effects on skin); ingestion (irritates gastrointestinal tract).

**FIRST AID:** wash eyes thoroughly with running water; if breathing is difficult, remove to fresh air and get medical attention; if large amounts were swallowed, drink plenty of water and get medical advice; contact with skin is not expected to require first aid measures.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans; investigated as a mutagen and a reproductive effector.

**ACUTE HEALTH RISKS:** irritation of upper respiratory tract; coughing; gastrointestinal disturbances; mechanical irritation of eyes; no adverse skin effects expected.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; wear chemical safety goggles; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; a half-face dust/mist respirator is needed in areas where exposure would be above the permissible exposure level; in an event of a fire, wear self-contained breathing apparatus; use non-sparking tools and equipment.

**SPILL CLEAN-UP:** ventilate area of leak or spill; clean up spills in a manner that prevents dust dispersal into the air; reduce airborne dust and prevent scattering by moistening with water; pick up spill for recovery or disposal and place in a closed container; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** manage whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry location; maintain adequate ventilation; keep in tightly closed containers and protect against physical damage; isolate from oxidizers, sulfuric acid and nitric acid; avoid any source of heat or ignition..

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as the starting material in the fermentative production of butanol, glycerol, ethanol, and citric acids; used as a sweetening agent in foods and soft drinks, confectionery, syrups, preserves and jams; useful as a flavoring agent in pharmaceuticals; has also been used as an antioxidant, in the form of invert sugar (i.e., mixture of glucose and fructose) and as a substitute for glycerol; other uses include manufacture of ink and transparent soaps, and in the plastics and cellulose industry.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

**SULFUR DIOXIDE(SO<sub>2</sub>, 64.06)**

CAS/DOT IDENTIFICATION #: 7446-09-5/UN1079

**SYNONYMS:** sulfurous acid anhydride, sulfurous anhydride, sulfurous oxide, sulfur oxide.

**PHYSICAL PROPERTIES :** colorless gas; condenses at -10°C and ordinary pressure to a colorless liquid; strong suffocating odor; acid taste; soluble in ethanol, chloroform, ether, acetic acid, and sulfuric acid; moderately soluble in benzene, acetone and carbon tetrachloride; partly soluble in water; MP (-76°C, -104°F); BP (-10°C, 14°F); DN (1.434 g/mL liquid at 0°C); LSG (1.46 at -10°C); ST (28.59 mN/m liquid at 10°C); VS (0.368 cP liquid at 0°C, 0.0124 cP gas at 18°C); CP (39.9 J/K-mol gas at 25°C); HV (22.92 kJ/mol at 25°C); VD (2.264); VP (2538 mmHg at 21.1°C); OT (4.70 x 10<sup>-1</sup> ppm in air).

**CHEMICAL PROPERTIES:** nonflammable gas; extremely stable to heat, even up to 2000°C; reacts with water to form sulfurous acid (H<sub>2</sub>SO<sub>3</sub>); catalytically oxidized by air to sulfur trioxide (SO<sub>3</sub>); will slowly oxidize from sulfurous to sulfuric acid; reacts with alkaline materials such as sodium and potassium; reacts with some active metals like aluminum, brass, copper, and zinc; may corrode aluminum; corrosive when dissolved in water as sulfurous acid; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-320 kJ/mol liquid at 25°C, -296.8 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating Health 3, Flammability 0, Reactivity 0; nonflammable gas; reacts violently with acrolein, aluminum, cesium oxide, chlorates, chromium, manganese, potassium chlorate, sodium, sodium carbide, stannous oxide, fluorine, cesium acetylene carbide, and potassium acetylene carbide; reacts with water or steam to produce toxic and corrosive fumes; incompatible with halogens, lithium nitrate, metal acetylides, metals, metal oxides, polymeric tubing, potassium chlorate, and sodium hydride; use water spray or suitable agent for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (severe choking, irritation of eyes and lungs, respiratory depression, pulmonary vascular resistance, irritates upper respiratory tract, edema of the lungs and glottis, respiratory paralysis); contact (frostbite, eczema).

**FIRST AID:** wash eyes immediately with large amounts of water; flush affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human LCLo 1000ppm/10M; toxic effect: pulmonary system; inhalation-human TCLo 3 ppm/5D; toxic effect: pulmonary system; inhalation-human TCLo 12 ppm/1H; toxic effect: pulmonary system; dna damage-human lymphocyte 5700 ppb.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; rhinorrhea; choking; coughing; reflex bronchoconstriction; eye and skin burns; frostbite; corrosive irritant of mucous membranes; edema of the lungs and glottis; respiratory paralysis.

**CHRONIC HEALTH RISKS:** pulmonary vascular resistance; respiratory depression; other pulmonary effects; may alter genetic material; reproductive effects; may cause eczema.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm; ACGIH TLV STEL 5 ppm; OSHA PEL TWA 5 ppm (13 mg/m<sup>3</sup>); NIOSH REL TWA 2 ppm (5mg/m<sup>3</sup>); NIOSH REL STEL 5 ppm (13 mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear full protective clothing, such as boots, aprons, sleeves, etc.; rubber gloves are recommended; safety goggles and sulfur dioxide approved gas masks should be worn at all times; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill in order to disperse gas; allow gas to empty in open air and use water spray to cool and disperse vapors; if in liquid form, allow to vaporize or wash with mild caustic.

**DISPOSAL AND STORAGE METHODS:** absorb in alkali solution, or attempt to recover as sulfuric acid; bubble into mixture of soda ash and water and add calcium hypochlorite to slurry; neutralize and route to sewage plant; store in a cool, dry location with adequate ventilation; outside storage is preferred; isolate from oxidizing materials and alkalis.

**REGULATORY INFORMATION:** CA1; F2; Sf2; A1; A5; CAL; DOT hazard class/division (2.3); labels (poison gas).

**OTHER COMMENTS:** used in preserving fruits, vegetables, etc.; application for sulfur dioxide or sulfites to vegetables increases storage life, preserves color and flavor, and aids in retention of carotene and ascorbic acid; used as a disinfectant in breweries and food factories; used in the manufacture of sodium sulfate, sulfuryl chloride, thionyl chloride, organic sulfonates, glass, wine and vapor pressure barometers; useful in pulp bleaching, metal mining and refining, water treatment and food processing.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 10; 11; 12; 14.

## **SULFUR HEXAFLUORIDE (SF<sub>6</sub>, 146.06)**

**CAS/DOT IDENTIFICATION #:** 2551-62-4/UN1080

**SYNONYMS:** sulfur fluoride, sulfur (VI) fluoride.

**PHYSICAL PROPERTIES :** colorless, odorless gas; one of the heaviest known gases; density is approximately 5 times that of air; white, sublimable solid at low temperatures; molecules of gas characterized by symmetrical, octahedral structure; sparingly soluble in water; slightly soluble in ethanol; soluble in ether; 0.297 mL sulfur hexafluoride dissolves in 1.0 mL of transformer oil at 25°C and 1 atm; MP (-50.8°C, -59.4°F); BP (sublimes at -64°C, -83°F); DN (1.67 g/mL liquid at -100°C, 1.88 g/mL liquid at -50.8°C); VS (15.3μPa-s at 25°C); CP (97.0 J/K-mol gas at 25°C); HV (8.99 kJ/mol at 25°C); VD (5.11); VP (319 psia, 21.7 atm, 16,497 mmHg at 70°F); SV (2.5 ft<sup>3</sup>/lb at 21.1°C).

**CHEMICAL PROPERTIES:** high chemical stability and inertness; thermodynamically unstable, but kinetically stable gas; inert to nucleophilic attack; stable to water and to glass; does not attack glass; stable to silent electrical discharge; unchanged at 500°C (932°F); does not exchange fluorine with hydrogen fluoride; hazardous polymerization will not occur; FP (NA); LFL/UFL (NA); AT (NA); HF (-1220.5 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; NFPA rating (none); can contain variable quantities of the low-sulfur fluorides (e.g., sulfur pentafluoride) which are highly toxic; very reactive chemically, and corrosive in nature; materials can hydrolyze on contact with water to yield highly toxic and very corrosive hydrogen fluoride; may act as a simple asphyxiant when pure and in high concentrations; incompatible with disilane; may be explosive; hazardous decomposition products include monosulfur fluoride, tetrasulfur fluoride, sulfuryl fluoride, sulfurous fluoride, sulfuric fluoride, decasulfur difluoride and other toxic fluoride compounds; if cylinders are involved in a fire, keep cool with water spray.

**HEALTH SYMPTOMS:** inhalation (dizziness, drowsiness, fatigue, emotional upset, increased breathing rate, increased pulse rate, slight muscle incoordination, nausea, vomiting, convulsions asphyxia, unconsciousness).

**FIRST AID:** if inhaled, remove to fresh air; if unconscious or breathing is difficult, administer CPR with supplemental oxygen; keep warm and at rest; obtain medical attention in all cases.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** asphyxia; increased breathing rate and pulse rate; slight muscle incoordination; nausea; vomiting; emotional upset; convulsions; loss of consciousness.

**CHRONIC HEALTH RISKS:** excludes an adequate supply of oxygen to the lungs resulting in dizziness, drowsiness, and eventual unconsciousness.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm (5970 mg/m<sup>3</sup>); OSHA PEL TWA 1000 ppm (6000 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (6000 mg/m<sup>3</sup>); IDLH not determined.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles; a system of local/mechanical exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into the general work area; in event of major leak, self-contained breathing apparatus may be required; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** evacuate all personnel upwind and away from affected area; stop leak if possible; if leaking containers are in an enclosed area, ventilate to acceptable respirable oxygen level before entering.

**DISPOSAL AND STORAGE METHODS:** locate leaking containers in a remote downwind area outside and allow to vent to atmosphere; dispose of in accordance with federal, state, and local regulations; store in a cool, dry, well-ventilated area; keep away from sources of heat and direct sunlight; protect cylinders against physical damage; cylinder should be stored upright and firmly secured to prevent falling or being knocked over; product is stable at elevated temperatures (> 400°F) if contained in aluminum, copper, silver, brass or stainless steel.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (2.2); labels (nonflammable gas).

**OTHER COMMENTS:** used in electrical circuit interrupters and in electronic ultra-high frequency piping; other uses include fertilizers, chemicals, dyes and pigments, electroplating baths, industrial explosives, nonferrous metallurgy, rayon and film, and iron and steel industry; useful as an etchant, and alkylation catalyst, and a lab reagent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **SULFURIC ACID (H<sub>2</sub>SO<sub>4</sub>, 98.08)**

**CAS/DOT IDENTIFICATION #:** 7664-93-9/UN1830

**SYNONYMS:** battery acid, chamber acid, fertilizer acid, hydrogen sulfate, oil of vitriol, sulfuric acid (aqueous).

**PHYSICAL PROPERTIES** : colorless to brown oily liquid; viscous liquid; odorless; pure compound is a solid below 51°F; often used in aqueous solution; miscible with water and alcohol with concentrated volume; MP(10.49°C, 51°F); BP(290°C, 554°F); DN(1.834 g/mL at 20°C); LSG (1.84); CP(138.9 J/K-mol liquid at 25°C); VP(1 mmHg at 145.8°C).

**CHEMICAL PROPERTIES**: noncombustible liquid; very reactive; dissolves most metals; concentrated acid oxidizes, dehydrates or sulfonates most organic compounds; very high affinity for water; abstracts water from air and also from many organic substances, often charring sugar, wood, etc.; evolves heat from upon mixing with water; corrosive to metals; reacts with alkalis, releasing heat; reacts with metals, releasing hydrogen gas; reacts with picrates, chlorates, nitrates, and many other materials; FP (NA); LFL/UFL (NA); AT (NA); HC(NA); HF (-814.0 kJ/mol liquid at 25°C); H<sub>f</sub> (10.71 kJ/mol at 283.46 K).

**EXPLOSION and FIRE CONCERNS**: not combustible; capable of igniting finely divided combustible materials on contact; NFPA rating Health 3, Flammability 0, Reactivity 2; reacts violently with water with heat evolution that causes explosive spattering; reaction with metals may produce hydrogen gas; very powerful acidic oxidizer; ignites on contact with acetic acid, acetone cyanhydrin, acetone + nitric acid, acetonitrile, acrolein, allyl alcohol, allyl chloride, ammonium hydroxide, 2-amino ethanol, ammonium azide, carbides, chlorates, and chlorosulfonic acid; explosive reaction with diisobutylene, e-pichlorohydrin, ethylene glycol, ethylene imine, mesityl oxide, p-nitrotoluene, picrates, potassium tert-butoxide, potassium permanganate, propylene oxide, pyridine, steel, styrene monomer, and vinyl acetate; can react vigorously with oxidizing or reducing materials; oxides of sulfur may be produced in a fire; use dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (irritates upper respiratory tract, loss of consciousness, pulmonary edema, bronchitis, emphysema, erosion of teeth); contact (rapid destruction of tissue, severe burns, shock, collapse, dermatitis).

**FIRST AID**: wash eyes immediately with large amounts of water for several minutes; flush affected areas of skin with plenty of water; provide respiratory support.

**HUMAN TOXICITY DATA**: inhalation-human TCLo 3 mg/m<sup>3</sup>/24W; unreported-man LDLo 135 mg/kg.

**ACUTE HEALTH RISKS**: irritation of eyes, nose, and throat; pulmonary edema; conjunctivitis; skin and eye burns; bronchitis; tracheobronchitis; rapid destruction of tissue; shock; collapse; rapid loss of consciousness; chemical pneumonitis; stomatis.

**CHRONIC HEALTH RISKS**: chronic bronchitis; emphysema; severe inflammation of upper respiratory tract; severe lung damage; dermatitis.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 1mg/m<sup>3</sup>; ACGIH TLV STEL 3ppm; OSHA PEL TWA 1 mg/m<sup>3</sup>; NIOSH REL TWA 1 mg/m<sup>3</sup>; IDLH 15 mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear rubber over-clothing, including gloves; wear splash-proof safety goggles and self-contained breathing apparatus; showers and eye fountains must be available where sulfuric acid is used.

**SPILL CLEAN-UP**: stop leak if possible; neutralize spill and/or washings with soda ash or lime, do not use water; using a clean shovel, place material into clean, dry container and cover.

**DISPOSAL AND STORAGE METHODS**: may be placed in sealed containers or absorbed in sand or inert absorbent for disposal in a secured, sanitary landfill; may also be diluted

and neutralized; store in corrosion-proof area; keep containers out of sun and away from heat; keep containers tightly closed.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 1000 lbs (454 kg); Sf1; Sf2; Sf3; CW1; CW2; A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used in manufacture of fertilizers, dyes and pigments, explosives, electroplating baths, parchment paper, glue, and other acids; useful as a lab reagent; used as an alkylation catalyst and in the purification of petroleum.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 12; 14.

### **SULFUR MONOCHLORIDE (S<sub>2</sub>Cl<sub>2</sub>, 135.02)**

**CAS/DOT IDENTIFICATION #:** 10025-67-9/UN1828

**SYNONYMS:** disulfur chloride, sulfur chloride, sulfur subchloride, thiosulfurous dichloride.

**PHYSICAL PROPERTIES :** light amber to yellowish-red, oily liquid; fuming liquid; pungent, nauseating odor; soluble in alcohol, ether, benzene, carbon disulfide, carbon tetrachloride, amyl acetate, and oils; readily dissolves up to 67% sulfur at room temperature; MP (-77°C, -107°F); BP (138°C, 280°F); DN (1.6885 g/mL at 15.5°C); LSG (1.68); VD (4.66); VP (6.8 mmHg at 20°C, 10 mmHg at 27.5°C); OT (NA).

**CHEMICAL PROPERTIES:** combustible liquid; corrosive; water reactive; hydrolyzes to hydrogen chloride and sulfur dioxide and hydrogen sulfide; can react with oxidizing materials; reacts with alcohols; forms pentathionic and other polythionic acids in acid solutions; decomposes on contact with water; FP (118°C, 245°F); LFL/UFL (NA); AT (234°C, 453°F); HF (-59.4 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 3, Flammability 1, Reactivity 1; contact with water causes a violent reaction, forming hydrochloric acid, sulfur dioxide, sulfur, sulfite, thiosulfate, and hydrogen sulfide; temperatures above 572°F (300°C) cause decomposition to toxic chlorine gas and solid sulfur; corrosive to metals; dangerous fire hazard when in contact with organic matter, phosphorus trioxide, sodium peroxide, chromyl dichloride, and water; will react with water or steam to produce heat and toxic and corrosive fumes; incompatible with peroxides, oxides of phosphorus, and some organic matter; toxic gases and vapors, such as hydrogen chloride, sulfur dioxide, hydrogen sulfide, and carbon monoxide may be released in a fire; use dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (difficulty in breathing, chemical pneumonia, irritates skin, eyes and mucous membranes); contact (coughing, tearing and burning of eyes, severe skin burns, immediate damage and scarring to eyes).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and do not induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and mucous membranes; lacrimation, coughing; severe eye and skin burns; pulmonary edema; severe difficulty in breathing; chemical pneumonia.

**CHRONIC HEALTH RISKS:** chronic irritation of skin, eyes, and upper respiratory tract; injury to the bronchioles and alveoli; permanent scarring of the eyes and skin.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 1 ppm; OSHA PEL TWA 1 ppm (6 mg/m<sup>3</sup>); NIOSH REL CL 1 ppm (6 mg/m<sup>3</sup>); IDLH 5 ppm.

**PERSONAL PROTECTION:** use impervious clothing, gloves, and face shields; use splash-proof safety goggles; wear self-contained breathing apparatus operated in positive pressure mode; facilities for quick drenching of the body and an eyewash fountain should be provided within immediate work area.

**SPILL CLEAN-UP:** absorb in noncombustible materials such as dry earth, sand or vermiculite; shovel into suitable dry container; keep water away from release; cover spill with a thick layer of dry soda ash and slaked lime mixture.

**DISPOSAL AND STORAGE METHODS:** spray on a thick layer of a mixture of dry soda ash and slaked lime; slowly mix and spray on water, and then add large amounts of water; dispose of neutralized solution in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; storage should be in tightly closed containers and out of contact with water; isolate from oxidizing materials.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (8); labels (corrosive).

**OTHER COMMENTS:** used as an intermediate and chlorinating agent in the manufacture of organic chemicals, sulfur dyes, synthetic rubbers, and insecticides; used as a cross-linking catalyst in polymer technology; use for cold vulcanizing of thin rubber articles; useful as a solvent for sulfur and sulfur compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 14; 16.

### **SUFLUR PENTAFLUORIDE (S<sub>2</sub>F<sub>10</sub>, 254.12).**

**CAS/DOT IDENTIFICATION #:** 5714-22-7/NA

**SYNONYMS:** disulfur decafluoride, sulfur decafluoride.

**PHYSICAL PROPERTIES :** colorless liquid or gas (above 84°F); odor like sulfur dioxide; insoluble in water; MP (-55°C, -67°F); BP (29°C, 84°F); LSG (2.08 at 0°C); VD (8.88); VP (561 mmHg at 20°C); OT (NA).

**CHEMICAL PROPERTIES:** noncombustible liquid or nonflammable gas; stable to water in the presence of acid or base; disproportionates at 1°C to sulfur tetrafluoride and sulfur hexafluoride; no reactivities or incompatibilities reported.

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating (NA); temperatures above 752°F (400°C) cause decomposition and development of pressure in containers; no incompatibilities; heating to decomposition emits very toxic fumes of fluorides and oxides of sulfur.

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**HEALTH SYMPTOMS:** inhalation (severe breathing difficulties, irritates eyes, skin and respiratory system).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water immediately to dilute the sulfur pentafluoride.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; pulmonary edema; hemorrhage.

**CHRONIC HEALTH RISKS:** no known chronic health risks reported in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.01 ppm; OSHA PEL TWA 0.025 ppm (0.25 mg/m<sup>3</sup>); NIOSH REL CL 0.01 ppm (0.1 mg/m<sup>3</sup>); IDLH 1 ppm.

**PERSONAL PROTECTION:** use impervious clothing, gloves, and face shields; use splash-proof safety goggles; wear self-contained breathing apparatus operated in positive pressure mode; facilities for quick drenching of the body and an eye-wash fountain should be provided in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak; stop flow of gas if possible; if source of leak is a cylinder, remove leaking cylinder to a safe place in open air and allow the cylinder to empty; if liquid, allow liquid to evaporate.

**DISPOSAL AND STORAGE METHODS:** locate leaking containers in a remote downwind area outside and allow to vent to atmosphere; dispose of in accordance with federal, state, and local regulations; store in a cool, dry, well-ventilated area; keep away from sources of heat and direct sunlight; protect cylinders against physical damage; cylinder should be stored upright and firmly secured to prevent falling or being knocked over.

**REGULATORY INFORMATION:** A1; A5; CAL.

**OTHER COMMENTS:** sulfur pentafluoride is considered more toxic than phosgene and is not produced commercially; liberated as a by-product during the synthesis of sulfur hexafluoride; exit vapors may be absorbed by activated alumina and soda lime.

**KEY REFERENCES:** 4; 5; 6; 7; 16.

### SULFURYL FLUORIDE (S<sub>0</sub>F<sub>2</sub>,102.6)

**CAS/DOT IDENTIFICATION #:** 2699-79-8/UN2191

**SYNONYMS:** sulfur difluoride dioxide, sulfuric oxyfluoride, sulphuryl difluoride, vikane<sup>®</sup>, vikane<sup>®</sup> fumigant.

**PHYSICAL PROPERTIES:** colorless, compressed gas; odorless; slightly soluble in cold water and alkalis; miscible with methyl bromide; sparingly soluble in most organic solvents, including ethanol, toluene, and carbon tetrachloride; MP (-135.82°C, -212.48°F); BP (-55.38°C, -67.68°F); DN(3.72 g/L gas, 1.7 g/L liquid); CP (66.0 J/K-mol gas at 25°C); VD (3.5); VP (12,750 mmHg at 21.1°C, 9150 mmHg at 10°C).

**CHEMICAL PROPERTIES:** fairly inert gas; not very reactive; stable to light; stable up to about 500°C (932°F) when dry; rapidly hydrolyzed by sodium hydroxide solution; not hydrolyzed by water; FP (NA); LFL/UFL (NA) AT (NA), HC (NA); T<sub>c</sub> (-20°C, -4°F).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; NFPA rating (none); non-corrosive; high temperatures may cause cylinders to burst; ruptured cylinders may rocket; some may burn, but none ignite readily; vapors from liquefied gas are initially heavier than air and spread along ground; can react with water or steam; hazardous decomposition products include poisonous gases and vapors, such as sulfur dioxide and hydrogen fluoride; use dry chemical, carbon dioxide, water spray, fog or regular foam for fire fighting purposes.

**HEALTH SYMPTOMS:** inhalation (nose bleeds, coughing, phlegm, tightness in chest, build-up of fluid in the lungs, severe shortness of breath, nausea, vomiting, tremors, convulsions); eye contact (pain, swelling, lacrimation, photophobia, conjunctivitis); skin contact (liquid can cause frostbite and tissue damage).

**FIRST AID:** if eye tissue is not frozen, immediately flush eyes with large amounts of water for several minutes; if eye tissue is frozen, seek prompt medical attention; wash affected areas of skin with plenty of soap and water, if frostbite has not occurred; if frostbite has occurred, seek medical attention immediately; provide oxygen if breathing is difficult; begin rescue breathing if breathing has stopped; transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of nose, throat, and bronchial tubes; epistaxis (nosebleeds); cough; phlegm; tightness in chest; dyspnea; pulmonary edema; nausea; vomiting; crampy abdominal pain; itching; muscle twitching; tremors; seizures; conjunctivitis; rhinorrhea; pharyngitis; paresthesia; weakness; anorexia; cardiopulmonary arrest; ventricular fibrillation; liquid may cause frostbite.

**CHRONIC HEALTH RISKS:** repeated exposure can cause reduced lung and kidney function; can also cause fluoride to accumulate in the body; excess fluoride can damage bones and teeth.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 ppm (21 mg/m<sup>3</sup>); ACGIH TLV STEL 10 ppm (42 mg/m<sup>3</sup>), OSHA PEL TWA 5 ppm (20 mg/m<sup>3</sup>); NIOSH REL TWA 5 ppm (20 mg/m<sup>3</sup>); NIOSH REL STEL 10 ppm (40 mg/m<sup>3</sup>); IDLH 200 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing to prevent the skin from becoming frozen from contact with the evaporating liquid; wear protective gloves and chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where the potential exists for exposures over 5 ppm; in high vapor concentrations, wear self-contained breathing apparatus or full face gas mask with acid gas/organic vapor canister; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of leak to disperse the gas; stop flow of gas without risk, if possible; turn leaking containers so that gas escapes rather than liquid; use water spray to reduce vapors or divert vapor cloud drift; prevent entry into waterways, basements or confined areas such as sewers; isolate area until gas has dispersed.

**DISPOSAL AND STORAGE METHODS:** a disposal method that has been suggested is to allow gas to flow into a mixed solution of caustic soda and slaked lime; consult with environmental regulatory agencies for guidance on acceptable disposal practices prior to imple-

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menting land disposal of waste sludge; may be stored in compressed form in steel cylinders or in gasometer over sulfuric acid; store cylinders upright in a secured, well-ventilated area away from heat; avoid contamination and keep away from food, feedstuffs, or drugs; all full and partially used or empty cylinders must have the valve closed and the valve cover hood securely in place when not in use.

**REGULATORY INFORMATION:** Sf3; A1; CAL; DOT hazard class/division (2.3); label (poison gas).

**OTHER COMMENTS:** an insecticide used for fumigating structures, vehicles, and wood products to control dry wood termites and wood-infesting beetles; used in the organic synthesis of drugs and dyes; useful as a fumigant for control of Blattodea, Coleoptera, Isoptera, Lepidoptera and rodents.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 14; 15; 16.

### 2,4,5-T( $\text{Cl}_3\text{C}_6\text{H}_2\text{OCH}_2\text{COOH}$ , 255.48).

**CAS/DOT IDENTIFICATION #:** 93-76-5/UN2765

**SYNONYMS:** dinoxol, esterone 245, 2,4,5-trichlorophenoxyacetic acid, trioxone, weedone.

**PHYSICAL PROPERTIES :** colorless to light-tan crystalline solid; odorless; usually has 2,3,7,8-tetrachlorobenzo-p-dioxin (TCDD) as a minor component; soluble in alcohol; insoluble in water; very slightly soluble in petroleum ether; forms water-soluble sodium and alkanolamine salts; commercial products are usually in the form of esters or amines, often in mixture with 2,4-dichlorophenoxyacetic acid (2,4-D); MP (151-153°C, 304-307°F); BP (decomposes above melting point at 760 mmHg); DN (1.80 g/cm<sup>3</sup> at 20°C); SG (1.80); VD (NA); VP (< 1 x 10<sup>-7</sup> mmHg at 20°C).

**CHEMICAL PROPERTIES:** combustible solid; stable at its melting point; non-corrosive, but some oil-based formulations may attack painted surfaces; no incompatibilities reported; FP (NA); LFL/UF (NA); AT (NA); HC (-6,500 Btu/lb).

**EXPLOSION and FIRE CONCERNS:** combustible solid, but burns with difficulty; NFPA rating (NA); toxic gases and vapors, such as hydrogen chloride, carbon monoxide, and phosgene gases may be released when 2,4,5-T decomposes; temperatures above 158°C (316°F) may cause sealed metal containers to burst; use water, dry chemicals, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (fatigue, weakness, nausea, lowered blood pressure, convulsions, coma); ingestion (vomiting, diarrhea, abdominal pain, blood in stool); contact (acne-like rash, irritation of eyes).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water immediately and induce vomiting..

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** nausea; vomiting; abdominal pain; diarrhea; blood in stool; irritation of skin and eyes; convulsions; ventricular fibrillation; cardiac arrest; coma; death.

**CHRONIC HEALTH RISKS:** weakness; lethargy; anorexia; severe acne form dermatitis; liver damage; may cause reproductive effects; lowered blood pressure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 10 mg/m<sup>3</sup>; NIOSH REL TWA 10 mg/m<sup>3</sup>; IDLH 250 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** rubber gloves, hats, suits, and boots must be worn; use dust- or splash-proof safety goggles; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill; absorb as much liquid as possible in noncombustible materials such as dry earth, sand or vermiculite; collect spilled materials and deposit in sealed containers for disposal in a secured sanitary landfill.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in dry earth, sand or vermiculite and place in a secured sanitary landfill; dispose of in sealed containers in a secured sanitary landfill; pour into excess sodium bicarbonate, mix, dump into large quantity of water, and route to sewage plant; pour onto vermiculite in an open incinerator and cautiously ignite; dissolve in flammable solvent and burn in incinerator equipped with afterburner and scrubber; store in a cool, dry location with adequate ventilation; storage should be in sealed metal containers.

**REGULATORY INFORMATION:** S3; R3; R5; F waste # (F027); Reportable Quantity (RQ): 1000 lbs. (454kg); Sfl; A1; CAL.

**OTHER COMMENTS:** application as herbicide, defoliant, and plant hormone; the use of 2,4,5-T in the United States has been cancelled since 1985; the USEPA has classified some or all applications as Restricted Use Pesticides.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 16.

**TANTALUM, METAL AND OXIDE DUST** (The molecular formula for metallic tantalum is Ta. Its corresponding formula weight is 180.95. An example of an oxide dust of tantalum is tantalum pentoxide. Its molecular formula and corresponding formula weight is Ta<sub>2</sub>O<sub>5</sub> and 441.90, respectively.)

**CAS/DOT IDENTIFICATION #:** 7440-25-7 (metal)/none

**SYNONYMS:** (metallic tantalum) tantalum metal, tantalum – 181. (tantalum pentoxide) tantic acid anhydride, tantalum oxide, tantalum (V) oxide.

**PHYSICAL PROPERTIES:** The physical properties of metallic tantalum and tantalum pentoxide are provided for illustrative purposes. (metallic tantalum) steel-blue to gray solid or black powder; very hard, malleable, ductile metal; can readily be drawn in fine wires; odorless; insoluble in water; insoluble in acids, except hydrofluoric and fuming sulfuric acids; soluble in fused alkalis; MP (2996°C, 5425°F); BP (5425°C, 9797°F); DN/SG (16.65 (metal), 14.40 (powder)); CP (25.4 J/K-mol crystal at 25°C); VD (NA); VP (approximately 0 mmHg at 20°C); TS (130,000 psi); EC (8 x 10<sup>-6</sup> over range 20 – 1500°C). (tantalum pentoxide) white, microcrystalline, infusible powder; insoluble in water, acids, and alcohol; soluble in hydrogen fluoride; MP (1800°C, 3272°F); BP (NA); DN/SG (8.2); CP (135.1 J/K-mol crystal at 25°C); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** The chemical properties of metallic tantalum and tantalum pentoxide are provided for illustrative purposes. (metallic tantalum) stable under ordinary conditions of use and storage; hazardous polymerization will not occur; corrosion resis-

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tant to air, water, all concentrations of hot and cold sulfuric acid, hydrochloric, nitric, and acetic acids, hot and cold dilute sodium hydroxide, aqueous solutions of chlorine, and moist sulfurous atmospheres; very resistant to chemical attack; attacked by hydrofluoric and fuming sulfuric acids; slowly attacked by fused alkalis; absorbs several hundred times its volume of hydrogen at elevated temperatures; can combine with carbon and nitrogen; reacts with chlorine, fluorine, and oxygen only when heated; FP (NA); LFL/UFL (NA); AT (300°C, 572°F(layer), 630°C, 1166°F (cloud)); HC (data not found);  $H_f$  (36.57 kJ/mol at 3290K). (tantalum pentoxide) stable under ordinary conditions of use and storage; hazardous polymerization will not occur; very inert; not amphoteric (i.e., incapable of behaving either as an acid or a base); decomposes by fusing with potassium hydroxide or potassium hydrogen sulfate; forms potassium tantalate upon fusion with potassium hydroxide; FP (NA); LFL/UFL (NA); AT (NA); HC (data not found); HF (-2046.0 kJ/mol crystal at 25°C);  $H_f$  (120 kJ/mol at 2058K).

**EXPLOSION and FIRE CONCERNS:** metal is a combustible solid; dry powder undergoes spontaneous ignition in air; contact of metallic dust with strong oxidizers may cause fires and explosion; metal is incompatible with bromine trifluoride, fluorine, and lead chromate; tantalum pentoxide is incompatible with bromine trifluoride, chlorine trifluoride, and lithium; minimum explosion dust concentration is less than 200 g/cm<sup>3</sup> (0.2 g/L); use dry sand, dry dolomite, and dry graphite for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes and skin); contact (some industrial skin injuries have been reported).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; if breathing is difficult, provide oxygen; provide respiratory support if breathing has stopped.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes and skin; pulmonary irritation based on animal testing. (Note: systemic industrial poisoning due to this chemical is unknown).

**CHRONIC HEALTH RISKS:** carcinogenicity of this chemical has been questioned; experimental tumorigenic data has been reported.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5mg/m<sup>3</sup>; OSHA PEL TWA 5 mg/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; NIOSH REL STEL 10 mg/m<sup>3</sup>; IDLH 2500 mg (as Ta)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use dust-proof safety goggles; enclose operations and/or provide local exhaust ventilation at the site of chemical release; appropriate respirators are needed in areas where exposures are above the permissible exposure level; in unknown concentrations or IDLH conditions, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or release; cautiously collect spilled material and deposit in sealed containers for proper disposal; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** tantalum and tantalum pentoxide may be disposed of in a secured, sanitary landfill; store in a cool, dry location; maintain adequate ventilation; separate from strong oxidizing materials, bromine trifluoride, and lead chromate.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none); label (none required).

**OTHER COMMENTS:** used in the manufacture of electronic equipment such as electrolytic capacitors and high-voltage surge arrestors; used in fabrication of metals for manufacture of chemical and metallurgical processing equipment and heat exchangers; used in manufacture of tantalum carbide for working machinery; other uses include manufacture of surgical metals, mesh, clips, special optical glass, and glass-line equipment.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 16.

**TEDP** ( $C_8H_{20}O_5P_2S_2$ , 322.34).

**CAS/DOT IDENTIFICATION #:** 3689-24-5/UN1704

**SYNONYMS:** bladafum<sup>®</sup>, dithion, sulfotep, tetraethyl dithionopyrophosphate, tetraethyl dithiopyrophosphate, thio Tepp<sup>®</sup>.

**PHYSICAL PROPERTIES :** pale-yellow liquid; garlic-like odor; soluble in most organic solvents; almost insoluble in water; MP (NA); BP (136-139°C, 277-282°F at 2mmHg); DN (1.196 g/mL at 25°C); LSG (1.20); VD (NA); VP (0.0002 mmHg at 20°C); OT (NA).

**CHEMICAL PROPERTIES:** combustible liquid; corrosive to iron; can react with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating (NA); contact with strong oxidizers may cause fires and explosions; elevated temperatures may cause containers to burst; will attack some forms of plastics, rubber, and coatings; toxic gases and vapors such as sulfur dioxide, phosphoric acid mist, and carbon monoxide may be released when heated to decomposition; use carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (tightness in chest, wheezing due to bronchoconstriction and excessive bronchial secretion, laryngeal spasms, excessive salivation, tearing of eyes, rhinorrhea, frontal headache, miosis, cyanosis); ingestion (anorexia, nausea, vomiting, abdominal cramps, diarrhea); skin absorption (localized sweating, muscular fasciculations, involuntary twitching, paralysis, ataxia, confusion, giddiness, slurred speech, Cheyne-Stokes respiration, loss of reflexes, convulsions, low blood pressure, cardiac irregularities, complete blockage of heart; coma).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** blurred vision; eye pain; lacrimation; wheezing; tightness of the chest; bluish discoloration of skin; small pupils; headache; watering of the mouth; rhinorrhea; loss of appetite; nausea; vomiting cramps; diarrhea; local sweating; weakness; twitching; paralysis; cessation of respiration; dizziness; confusion; staggering; slurred speech; irregular or slow heartbeat; convulsions; low blood pressure; coma.

**CHRONIC HEALTH RISKS:** anorexia; causes depressed levels of cholinesterase in the blood; continued daily exposure may make a person more susceptible to the effects of this and related chemicals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.2 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.2 mg/m<sup>3</sup>(skin); IDLH 10 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear self-contained breathing apparatus in high vapor concentrations; wear boots, gloves, aprons, etc; wear splash-proof safety goggles; an eye-wash fountain and facilities for quick drenching of the body should be provided within immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible in non-combustible materials such as dry earth, sand, or vermiculite.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite and place in sealed containers in a secured sanitary landfill; store in suitably protected and well-ventilated interior areas at ambient temperature; outdoor storage is preferred; keep away from strong oxidizing materials.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the formulation of insecticides and miticides; use may be restricted.

**KEY REFERENCES:** 3; 4; 5; 6; 7;16.

**TELLURIUM and COMPOUNDS (as Te)** (Tellurium compounds have variable molecular formulas. The molecular formula for tellurium is Te. The molecular formulas for hydrogen telluride and potassium tellurite are  $H_2Te$  and  $K_2TeO_3$ , respectively. Tellurium compounds have variable formula weights. The formula weight for tellurium is 127.60. The formula weights for hydrogen telluride and potassium tellurite are 129.6 and 253.8, respectively.)

**CAS/DOT IDENTIFICATION #:** Tellurium compounds have variable CAS #'s. The CAS # for tellurium is 13494-80-9. The DOT identification number for tellurium is UN2811.

**SYNONYMS:** Synonyms vary depending upon the specific tellurium compound. (tellurium) aurum paradoxum, metallum pobleatum, tellurium, metallic. (hydrogen telluride) dihydrogen telluride, tellurium hydride. (potassium tellurite) potassium tellurate (IV).

**PHYSICAL PROPERTIES :** Physical properties vary depending upon the specific tellurium compound. (tellurium) dark gray to brown, amorphous powder or silvery-white, lustrous, crystalline solid with metal characteristics; red when colloidal; forms golden-yellow vapor; soluble in nitric acid, potassium hydroxide, sulfuric acid, and potassium cyanide solutions; insoluble in water, benzene, and carbon disulfide; MP (449.5°C, 841°F); BP (989.8°C, 1813.6°F); DN (6.11-6.27 g/cm<sup>3</sup> crystal); SG (6.11-6.27); CP (25.7 J/K-mol crystal at 25°C); HV (114.1 kJ/mol at 1261K); VD (NA); VP (1 mmHg at 52) °C. (hydrogen telluride) colorless gas; characteristic odor like arsenic or offensive, garlic-like odor; soluble in water, alcohol and alkalies; MP (-50°C, -58°F); BP (-2°C, 28°F); DN (2.57 g/mL liquid at -20°C); LSG (2.6); HV (19.2 kJ/mol at 271K); VD (4.5); VP (approximately 1600 mmHg at 20°C). (potassium tellurite) granular, white powder; hygroscopic; odorless; very soluble in water; MP (450°C, 842°F); BP (decomposes); DN/SG (data not available); VD (NA); VP (approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** Chemical properties vary depending upon the specific tellurium compound. (tellurium) p-type semiconductor; poor conductor of heat; burns in air with a greenish-blue flame, forming the dioxide; reacts with nitric acid; forms a red solution on reaction with concentrated or fuming sulfuric acid; reacts vigorously with halogens or in-

terhalogens; dissolves in potassium hydroxide in presence of air, forming a deep-red solution; does not react with selenium or sulfur; FP (NA); LFL/UFL (NA); AT (340°C, 644°F);  $H_f$  (17.49 kJ/mol at 722.66K); ER (200,000  $\mu\text{ohm-cm}$  at 19.6°C);  $T_c$  (0.014 at 20°C). (hydrogen telluride) unstable, but is rarely worked with as such; dry gas is stable to light; liquid form is decomposed in presence of light; dry gas decomposes in presence of dust, traces of moisture, cork, rubber, etc.; FP (NA); LFL/UFL (NA); AT (NA); HF (99.6 kJ/mol gas at 25°C). (potassium tellurite) decomposes at 460°C-470°F (860-878°F); FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** tellurium is a moderate fire hazard in form of dust when exposed to heat or flame; finely disperse particles of tellurium form explosive mixtures in air; contact of tellurium metal or hydrogen telluride with strong oxidizers may cause fires and explosions; tellurium metal reacts vigorously with halogens, interhalogens and metals, causing flames hazard; tellurium undergoes incandescent reactions with zinc and lithium silicide; when tellurium and potassium tellurite are heated to decomposition, toxic fumes of Te and toxic fumes of  $\text{K}_2\text{O}$  and Te are emitted, respectively; use foam, dry powder or carbon dioxide for fire-fighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, sleepiness, garlic breath, nausea; skin absorption (tremors, convulsions, respiratory arrest, central nervous system depression); ingestion (abdominal pain, nausea, vomiting, constipation, garlic odor of breath).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; perform artificial respiration if breathing has stopped; in case of ingestion, give a slurry of activated charcoal in water to drink; seek immediate medical attention.

**HUMAN TOXICITY DATA:** no  $\text{LD}_{50}/\text{LC}_{50}$  information found relating to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to respiratory tract; headache; garlic odor on breath; sweat; dryness of the mouth; metallic taste; drowsiness; nausea; vomiting; abdominal pain; constipation; loss of appetite; tellurium dioxide exposure may cause a temporary loss of sweat function.

**CHRONIC HEALTH RISKS:** prolonged exposure may cause dermatitis; animal tests show that this substance may cause malformations in human babies; has produced irritation of the lungs and destruction of red blood cells in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1  $\text{mg}(\text{Te})/\text{m}^3$ ; OSHA PEL TWA 0.1  $\text{mg}(\text{Te})/\text{m}^3$ ; NIOSH REL TWA 0.1  $\text{mg}(\text{Te})/\text{m}^3$ ; IDLH 25  $\text{mg}(\text{Te})/\text{m}^3$ .

**PERSONAL PROTECTION:** wear impervious protective clothing, including chemical-resistant gloves, apron or coveralls; wear chemical safety goggles in combination with breathing protection if powder; a closed system of local exhaust ventilation is preferred to control emissions at the source and to prevent dispersion into the general work area; use dust explosion-proof electrical equipment and lighting; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus in high vapor concentrations; for extra personal protection, use P3 filter respiratory or toxic particles; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; sweep spilled substance into sealed containers for disposal in a designated landfill; absorb liquid containing tellurium and compounds with noncombustible materials (e.g., dry earth, sand, or vermiculite); for hydrogen telluride, stop flow of gas if possible; if source of leak is a cylinder, cautiously remove leaking cylinder to a safe place in open air, and allow cylinder to empty.

**DISPOSAL AND STORAGE METHODS:** tellurium and compounds may be disposed of in sealed containers in a secured, sanitary landfill; store in a cool, dry location; use with adequate ventilation; storage should be in tightly closed container; separate from strong oxidizers, strong acids, strong bases, halogens, and interhalogens.

**REGULATORY INFORMATION:** Sf2; CAL; DOT hazard class/division (6.1); label (poison).

**OTHER COMMENTS:** tellurium may be used as a coloring agent in chinaware, enamels, porcelains, and glass; utilized in the manufacture of special alloys of marked electrical resistance; has also been used in the manufacture of electronic devices such as batteries, solar cells, semiconductors, and during the manufacture of tellurium compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14; 16.

### **TELLURIUM HEXAFLUORIDE (TeF<sub>6</sub>, 241.60)**

**CAS/DOT IDENTIFICATION #:** 7783-80-4/UN2195

**SYNONYMS:** tellurium fluoride, tellurium (VI) fluoride.

**PHYSICAL PROPERTIES :** colorless gas; exists as a white solid at low temperatures; repulsive odor; sublimes before melting; slowly absorbed by water; MP(-37.6°C, -35.7°F) (triple point); BP(-38.9°C, -38°F) (sublimes); DN (4.006 g/cm<sup>3</sup> solid at -191°C, 2.499 g/mL liquid at -10°C); VD (8.34); VP (> 1 atm at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hydrolyzes slowly in water to telluric acid (H<sub>6</sub>O<sub>6</sub>Te); more quickly hydrolyzed by aqueous potassium hydroxide; when pure, does not attack glass; corrosive to mercury; not as chemically inert as sulfur hexafluoride (SF<sub>6</sub>) and selenium hexafluoride (SeF<sub>6</sub>) because the maximum covalence of tellurium is greater than six; FP (NA); LFL/UFL(NA); AT(NA); HC(NA); HF(-1318.0 kJ/mol gas at 25°C); T<sub>c</sub> (83°C, 181.4°F).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; not combustible; not expected to be a fire hazard; not expected to be an explosion hazard; slowly absorbed by water with hydrolysis to telluric acid, which has a strong tendency to polymerize; heating to decomposition emits toxic gases and vapors (such as hydrogen fluoride); in case of fire in the surroundings, use dry powder, carbon dioxide or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, difficulty in breathing, garlic breath, irritates respiratory system).

**FIRST AID:** after breathing in large amounts of tellurium hexafluoride, move to fresh air; if breathing has stopped, perform artificial respiration; get immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> data found relating to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** headache; dyspnea; garlic odor on breath; may cause severe irritation of respiratory tract; has been known to cause pulmonary edema in animals.

**CHRONIC HEALTH RISKS:** chronic respiratory disease; human skin (systemic) effects have been reported; no other systemic effects have been reported from industrial exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.02 ppm (as Te); OSHA PEL TWA 0.02 ppm (as Te) (0.2 mg/m<sup>3</sup>); NIOSH REL TWA 0.02ppm (as Te) (0.2 mg/m<sup>3</sup>); IDLH 1ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, and gas-tight suit; wear chemical safety goggles; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of leak to disperse gas; stop flow of gas if possible; if source of leak is a cylinder, cautiously remove leaking cylinder to a safe place in open air and allow the cylinder to empty; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; store in a cool, dry well-ventilated location; outside storage is preferred; must be stored in a dry location.

**REGULATORY INFORMATION:** Sf2; A1; A5; CAL; DOT hazard class/division (2.3); label (poison).

**OTHER COMMENTS:** used in scientific studies on physical and chemical properties such as electron diffraction, crystal structure, magnetic spin, force constants spectra, and corrosive action.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14.

### **TEMEPHOS (C<sub>16</sub>H<sub>20</sub>O<sub>6</sub>P<sub>2</sub>S<sub>3</sub>, 466.48)**

**CAS/DOT IDENTIFICATION #:** 3383-96-8/UN2783

**SYNONYMS:** abate<sup>®</sup>, biothion<sup>®</sup>, nimitex<sup>®</sup>, swebate<sup>®</sup>, temefos<sup>®</sup>, 0,0,0',0'-tetramethyl-0,0'-thiodi-p-phenylene phosphorothioate.

**PHYSICAL PROPERTIES :** white, crystalline solid; exists as a liquid above 87°F; technical grade is a brown, viscous liquid; soluble in acetonitrile, carbon tetrachloride, dichloroethane, diethyl ether, and toluene; practically insoluble in water and hexane; MP (30-30.5°C, 86.0-87°F); BP (120-125°C, 248-257°F); DN (1.32 g/cm<sup>3</sup>); SG (1.32); VD (NA); VP (7 x 10<sup>-8</sup> mmHg at 77°F).

**CHEMICAL PROPERTIES:** combustible solid; optimum stability at pH 5-7; reacts with strong acids and bases (hydrolysis); decomposes at temperatures above the boiling point; FP (unknown); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating (NA); liquid formulations containing organic solvents may be flammable; incompatible with strong acids and bases; decomposes on heating or on burning producing toxic fumes of phosphorous oxides and oxides of sulfur; use water spray, powder, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, blurred vision, difficult breathing); skin absorption (dizziness, confusions, salivation); ingestion (nausea, vomiting, diarrhea, abdominal cramps, inhibits cholinesterase).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; flush affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; if not breathing provide respiratory support; in case of ingestion, rinse mouth and seek immediate medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes; blurred vision; dizziness; confusion; dyspnea (difficult breathing); salivation; abdominal cramps; nausea; vomiting; diarrhea; cholinesterase inhibitor in animals.

**CHRONIC HEALTH RISKS:** no information found; targets eyes, respiratory system, central nervous system, cardiovascular system, blood cholinesterase.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; a system of local exhaust ventilation (not if powder) is recommended to control emissions at the source and to prevent dispersion into general work area; use positive pressure self-contained breathing apparatus; for extra personal protection, a P3 filter respirator for toxic particles may be employed; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into covered containers; moisten first to prevent dusting; carefully collect remainder, then remove to a safe place; do not wash away into sewer.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an appropriate waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry, well-ventilated location; storage should be tightly closed containers; separate from food and feedstuffs.

**REGULATORY INFORMATION:** F2; Sf3; A1; CAL.

**OTHER COMMENTS:** used as a larvicide for mosquito and blackfly; substance is toxic to aquatic organisms; substance may be hazardous to the environment; particular attention should be given to honey bees.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### TEPP (C<sub>8</sub>H<sub>20</sub>O<sub>7</sub>P<sub>2</sub>, 290.22)

**CAS/DOT IDENTIFICATION #:** 107-49-3/UN3018

**SYNONYMS:** diphosphoric acid tetraethyl ester, ethyl pyrophosphate, tetraethyl diphosphate, tetraethyl pyrophosphate, tetron<sup>®</sup>, vapotone.

**PHYSICAL PROPERTIES :** colorless to amber liquid; hygroscopic; mobile liquid; faint, fruity odor; a solid below 32°F (0°C); miscible with water in all proportions; also miscible with methanol, ethanol, acetone, benzene, carbon tetrachloride, chloroform, ethylene glycol, glycerol, propylene glycol, xylene, and toluene; not miscible with kerosene, petroleum ether and other petroleum oils; MP (sets to glassy state below 0°C); BP (82°C, 179.6°F) at 0.05 mmHg; 124°C, 255°F at 1.0 mmHg; 138°C, 280.4°F at 2.3 mmHg); DN (1.185 g/mL at 20°C); LSG (1.2); VD (10); REL DN vapor/air mixture (1.00 at 20°C); VP (1.5 x 10<sup>-4</sup> mmHg at 20°C, 1 mmHg at 140°C); OT (NA).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; hydrolyzes quickly in water with formation of mono-, di-, and triethyl orthophosphate; will attack some forms of plastics, rubber, and coatings; temperatures ranging from 170-213°C (338-415°F) cause thermal decomposition with formation of ethylene; FP (NA); LFL/UFL (NA); AT (unknown in literature).

**EXPLOSION and FIRE CONCERNS:** noncombustible liquid; liquid formulations containing organic solvents may be flammable; risk of fire and explosion; NFPA rating (NA); contact with strong oxidizers may cause fires and explosions; attacks some forms of plastic, rubber and coatings corrosive to most metals; decomposes on heating producing above 150°C (302°F) flammable ethylene gas and toxic gases and vapors (such as oxides of phosphorus and carbon monoxide); use powder, alcohol foam, carbon dioxide, and large amounts of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, wheezing due to bronchoconstriction, bluish discoloration of skin, small pupils, runny nose, headache, dizziness, watering of mouth, nausea, muscle cramp, generalized sweating, convulsions, unconsciousness); skin absorption (sweating, twitching, weakness, paralysis, dizziness, confusion, staggering, slurred speech, giddiness, cardiac irregularities, low blood pressure, convulsions, coma); eye contact (miosis, aching in and behind eyes, blurring of distant vision, tearing, frontal headache); ingestion (anorexia, nausea, vomiting, abdominal cramps, diarrhea).

**FIRST AID:** wash eyes with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, give oxygen; provide artificial respiration if indicated; in case of ingestion; rinse mouth and give a slurry of activated charcoal in water to drink; get immediate medical attention.

**HUMAN TOXICITY DATA:** oral-human LDLo 1429µg/kg; toxic effect: peripheral nervous system, central nervous system, gastrointestinal tract; oral-human TDLo 309µg/kg; toxic effect: central nervous system, gastrointestinal tract; intramuscular-human LDLo 286µg/kg; toxic effect: peripheral nervous system, central nervous system, gastrointestinal tract; parenteral-human TDLo 71µg/kg; toxic effect: central nervous system, gastrointestinal tract.

**ACUTE HEALTH RISKS:** cough; wheezing; tightness of chest; labored breathing; excessive salivation; sweating; headache; dizziness; pupillary constriction; blurred vision; lacrimation; rhinorrhea; cyanosis; abdominal cramps; nausea; vomiting; diarrhea; loss of appetite; twitching; weakness; confusion; staggering; slurred speech; irregular or slow heartbeat; lowering of blood pressure; convulsions; respiratory failure; coma; causes depressed levels of cholinesterase in blood; death.

**CHRONIC HEALTH RISKS:** cholinesterase inhibitor (i.e., causes depressed levels of cholinesterase activity in the serum and erythrocytes); anorexia; cardiac irregularities; repeated exposure to this chemical may result in cumulative effect of acute hazards/symptoms.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.004 ppm (0.047 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 0.05 mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.05 mg/m<sup>3</sup> (skin); IDLH 5 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use splash-proof safety goggles in combination with breathing protection; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing protection apparatus; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect spilled liquid in sealable containers or absorb with an inert material (e.g., dry earth, sand, vermiculite); flush remaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of by absorbing in dry sand, earth, or vermiculite, and disposing in sealed containers in a secured, sanitary landfill; store in a cool, dry location; keep in a well-ventilated room; keep away from any area where the fire hazard may be acute; isolate from strong oxidizers; separate from food and feedstuffs.

**REGULATORY INFORMATION:** F1; Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf2; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as an insecticide on agricultural crops; also used in greenhouses; useful in the formulation of insecticides; substance may be hazardous to the environment; special attention should be given to birds, bees, mammals and water organisms.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14; 16.

### TERPHENYLS (C<sub>18</sub>H<sub>14</sub>, 230.2)

**CAS/DOT IDENTIFICATION #:** 26140-60-3/none

**SYNONYMS:** diphenylbenzenes, mixed terphenyls, meta-terphenyl, ortho-terphenyl, para-terphenyl, phenyl biphenyls, terbenzenes, triphenyls.

**PHYSICAL PROPERTIES:** colorless or light-yellow solids; there are three chemical isomers, the ortho, meta, and para derivatives; the ortho and para forms appear industrially most prevalent; all forms are solid at room temperature; all forms are soluble in benzene and ethanol, but are insoluble in water; order of solubility decreases from the ortho to the para form; their physical properties are as follows: MP (56.2°C, 133°F(ortho); 87.4°C, 189.3°F (meta); 212.7°C, 415°F (para)); BP (332.°C, 630°F (ortho); 365°C, 689°F (meta); 405°C, 761°F (para)); DN/SG (1.10 to 1.23); VD (not applicable); VP (very low at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; no incompatibilities and/or reactivities have been reported; FP (162.8 – 207.2°C, 325 – 405°F); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible solids; NFPA rating (not rated); no incompatibilities have been reported; not expected to be a fire hazard; not expected to be an explosion hazard; hazardous decomposition products, such as carbon monoxide, may be released in a fire involving terphenyls; use carbon dioxide or dry chemical for fire fighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, sore throat, irritates eyes, skin and mucous membranes); contact (thermal skin burns, dermatitis); ingestion (symptoms parallel those of inhalation).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; promptly wash affected areas of skin with plenty of water; if breathing is difficult, provide oxygen; begin rescue breathing if breathing has stopped; if terphenyls have been swallowed, do not induce vomiting; seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** (note: there are no well-documented studies showing the effects of terphenyls on humans). Exposure to terphenyls may cause eye, skin and respiratory irritation; have caused transient headache and sore throat; may also cause thermal skin burns and readily reversible skin rashes.

**CHRONIC HEALTH RISKS:** (note: there are no well-documented studies showing the effects of terphenyls on humans); Cases of dermatitis attributed to skin contact with terphenyls have been reported; may cause liver and kidney damage, as based on testing in animals.

**EXPOSURE GUIDELINES:** ACGIH TLV CL 0.53 ppm (5 mg/m<sup>3</sup>); OSHA PEL CL 1 ppm (9 mg/m<sup>3</sup>); NIOSH REL CL 0.5 ppm (5 mg/m<sup>3</sup>); IDLH (500 mg/m<sup>3</sup>).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use dust- and splash-proof safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; sweep small quantities onto paper or other suitable material, place in an appropriate container and cautiously burn in a fume hood; if appropriate, moisten first to prevent dusting; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** terphenyls may be disposed of by dissolving in a flammable solvent (such as alcohol) and atomizing in a suitable combustion chamber; store in well closed containers in a well-ventilated area at room temperature; keep away from heat or open flame; separate from food and feedstuffs.

**REGULATORY INFORMATION:** A1; DOT classification (none).

**OTHER COMMENTS:** terphenyls are important industrially as chemical intermediates in the manufacture of nonspreading lubricants, as heat transfer fluids, and as nuclear reactor coolants; are also used as constituents of waxes and polishes, and as plasticizers for resin-bodied paints; para-terphenyl has been used as a component of sunscreen lotion; the terphenyls are considered a non-significant industrial hazard due to their low vapor pressure.

**KEY REFERENCES:** 4; 5; 6; 7; 16; 18.

### **1,1,1,2-TETRACHLORO-2,2-DIFLUOROETHANE (CCl<sub>3</sub>CClF<sub>2</sub>, 203.82)**

**CAS/DOT IDENTIFICATION #:** 76-11-9/none

**SYNONYMS:** 1,1-difluoro-1,2,2,2-tetrachloroethane, 2,2-difluoro-1,1,1,2-tetrachloroethane, 1,1-difluoroperchloroethane, freon<sup>®</sup> 112a, halocarbon 112a, refrigerant 112a.

**PHYSICAL PROPERTIES:** colorless liquid or solid; slight ether-like odor; insoluble in water; soluble in alcohol, ether, and chloroform; MP (40.6°C, 105°F); BP (91.5°C, 196.7°F at 760 mmHg); DN (1.649 g/mL at 20°C); LSG (1.65); ST (31.7 dynes/cm at 30°C); CP (123.4 J/K-mol gas at 25°C); VD (7.0); VP (40 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; reacts with chemically active metals such as sodium, potassium, beryllium, powdered magnesium, aluminum, and zinc; will attack some

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forms of plastics, rubber, and coatings; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-489.9 kJ/mol gas at 25°C);  $H_f$  (3.7 kJ/mol at 299K);  $T_c$  (278°C, 532°F).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; not flammable; NFPA rating (not rated); some may burn, but none ignite readily; containers may explode when heated; ruptured cylinders may rocket; reacts violently with chemically active metals (such as sodium, potassium, beryllium, zinc, powdered aluminum, and magnesium); emits highly toxic chloride fumes on contact with acid or acid fume; will undergo thermal decomposition upon exposure to open flame or red-hot metal surface; hazardous decomposition products include hydrofluoric acid, hydrochloric acid, along with smaller amounts of phosgene and carbonyl fluoride; carbonyl fluoride is very unstable to hydrolysis, and in the presence of moisture, quickly changes to hydrofluoric acid and carbon dioxide; use dry chemical, carbon dioxide, water spray, fog or regular foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (confusion, pulmonary irritation, tremors, laryngeal spasm or edema, coughing, shortness of breath, dizziness, lightheadedness, irritates nose and throat); contact (irritates eyes and skin, causing a rash or burning feeling); ingestion (depression of central nervous system, dizziness, lightheadedness, liver damage, other symptoms parallel those of inhalation).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with large amounts of soap and water; administer oxygen if breathing is difficult; begin rescue breathing if breathing has stopped; in case of ingestion, transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** no  $LD_{50}/LC_{50}$  information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes and skin; rash or burning feeling; irritation to nose and throat; pulmonary edema; coughing; dyspnea (breathing difficulty); drowsiness; dizziness; lightheadedness; pulmonary irritation; tremors; laryngeal spasm; oxygen displacement; death from abuse of fluorocarbons.

**CHRONIC HEALTH RISKS:** repeated exposure may reduce the number of white blood cells or damage the liver; may worsen pre-existing respiratory conditions caused by chemical exposure, leading to chronic respiratory disease.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 500 ppm (4170 mg/m<sup>3</sup>); OSHA PEL TWA 500 ppm (4170 mg/m<sup>3</sup>); NIOSH REL TWA 500 ppm (4170 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust- and splash-proof safety goggles where liquid or solid may contact the eyes; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where the potential exists for exposures over 500 ppm; if the possibility of exposure above 2,000 ppm exists, use self-contained breathing apparatus operating in a positive-pressure mode; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; stop leak without risk, if possible; water spray may be used to reduce vapors, or divert vapor cloud drift; if in solid form, cautiously collect spilled material and deposit in sealed container; absorb liquids in dry earth, sand or vermiculite, and deposit in chemical waste containers.

**DISPOSAL AND STORAGE METHODS:** if in liquid form, absorb in sand or inert absorbent, and dispose of in a secured, sanitary landfill; if in solid form, dispose of in a designated

landfill; store in tightly closed containers in a cool, well-ventilated area; avoid contact with open flame or very hot surfaces; separate from incompatibles such as acids and chemically-active metals.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none).

**OTHER COMMENTS:** used in dry cleaning industry; in polymer and plastics industry as blowing or foaming agent; as a corrosion inhibitor in brake fluid and surface coatings on electrical equipment; as solvent extractor for separation and purification of biological materials; as a dye solvent to give brighter colors and to detect surface cracks or defects in metals; as a degreasing solvent.

**KEY REFERENCES:** 4; 5; 6; 7; 14; 15; 16.

### 1,1,2,2-TETRACHLORO-1,2-DIFLUOROETHANE (CCl<sub>2</sub>FCCl<sub>2</sub>F, 203.82)

**CAS/DOT IDENTIFICATION #:** 76-12-0/none

**SYNONYMS:** 1,2-difluoro-1,1,2,2-tetrachloroethane, freon<sup>®</sup>112, halocarbon 112, refrigerant 112.

**PHYSICAL PROPERTIES:** colorless liquid or white solid; slight, ether-like odor; slightly camphor-like odor when concentrated; insoluble in water; soluble in alcohol, ether, and chloroform; MP (26°C, 79°F); BP (92.8°C, 199°F); DN (1.6447 g/mL at 25°C); LSG (1.65 at 20°C); VD (7.03); VP (40 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; reacts with chemically active metals such as sodium, potassium, beryllium, powdered magnesium, aluminum, and zinc; will attack some forms of plastics, rubber, and coatings; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; not flammable; NFPA rating (not rated); some may burn, but none ignite readily; containers may explode when heated; ruptured cylinders may rocket; reacts violently with chemically active metals (such as sodium, potassium, beryllium, zinc, powdered aluminum, and magnesium); emits highly toxic chloride fumes on contact with acid or acid fume; will undergo thermal decomposition upon exposure to open flame or red-hot metal surface; hazardous decomposition products include hydrofluoric acid, hydrochloric acid, along with smaller amounts of phosgene and carbonyl fluoride; carbonyl fluoride is very unstable to hydrolysis, and in the presence of moisture, quickly changes to hydrofluoric acid and carbon dioxide; use dry chemical, carbon dioxide, water spray, fog or regular foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (confusion, pulmonary irritation, tremors, laryngeal spasm or edema, coughing, shortness of breath, dizziness, lightheadedness, irritates nose and throat); contact (irritates eyes and skin, causing a rash or burning feeling); ingestion (depression of central nervous system, dizziness, lightheadedness, liver damage, other symptoms parallel those of inhalation).

**FIRST AID:** flush eyes immediately with large amounts of water for several minutes; wash affected areas of skin with large amounts of soap and water; administer oxygen if breathing is difficult; begin rescue breathing if breathing has stopped; in case of ingestion, transfer promptly to a medical facility.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes and skin; rash or burning feeling; irritation to nose and throat; pulmonary edema; coughing; dyspnea (breathing difficulty); drowsiness; dizziness; lightheadedness; pulmonary irritation; tremors; laryngeal spasm; oxygen displacement; death from abuse of fluorocarbons.

**CHRONIC HEALTH RISKS:** repeated exposure may reduce the number of white blood cells or damage the liver; may worsen pre-existing respiratory conditions caused by chemical exposure, leading to chronic respiratory disease.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 500 ppm (4170 mg/m<sup>3</sup>); OSHA PEL TWA 500 ppm (4170 mg/m<sup>3</sup>); NIOSH REL TWA 500 ppm (4170 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; wear dust- and splash-proof safety goggles where liquid or solid may contact the eyes; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where the potential exists for exposures over 500 ppm; if the possibility of exposure above 2,000 ppm exists, use self-contained breathing apparatus operating in a positive-pressure mode; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; stop leak without risk, if possible; water spray may be used to reduce vapors, or divert vapor cloud drift; if in solid form, cautiously collect spilled material and deposit in sealed container; absorb liquids in dry earth, sand or vermiculite, and deposit in chemical waste containers.

**DISPOSAL AND STORAGE METHODS:** if in liquid form, absorb in sand or inert absorbent, and dispose of in a secured, sanitary landfill; if in solid form, dispose of in a designated landfill; store in tightly closed containers in a cool, well-ventilated area; avoid contact with open flame or very hot surfaces; separate from incompatibles such as acids and chemically-active metals.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none).

**OTHER COMMENTS:** used in dry cleaning industry; in polymer and plastics industry as blowing or foaming agent; as a corrosion inhibitor in brake fluid and surface coatings on electrical equipment; as solvent extractor for separation and purification of biological materials; as a dye solvent to give brighter colors and to detect surface cracks or defects in metals; as a degreasing solvent.

**KEY REFERENCES:** 4; 5; 6; 7; 14; 15; 16.

### **1,1,2,2-TETRACHLOROETHANE (CHCl<sub>2</sub>CHCl<sub>2</sub>, 167.87)**

**CAS/DOT IDENTIFICATION #:** 79-34-5/UN1702

**SYNONYMS:** acetylene tetrachloride, tetrachloroethane, symmetrical-tetrachloroethane, s-tetrachloroethane.

**PHYSICAL PROPERTIES :** clear, colorless liquid; heavy, mobile liquid; chloroform-like odor; very slightly soluble in water; miscible with methanol, ethanol, carbon tetrachloride, benzene, ether, petroleum ether, carbon disulfide, chloroform, dimethyl formamide, and

oils; highest solvent power of the chlorinated hydrocarbons; MP (-44°C, -47°F); BP (146°C, 295°F); DN (1.593 g/mL at 25°C); LSG (1.59 at 20°C); ST (35.58 mN/m at 25°C); CP (162.3 J/K-mol liquid at 25°C); HV (45.71 kJ/mol at 25°C); VD (5.8); REL DN vapor/air mixture (1.031 at 20°C); VP (8 mmHg at 20°C); OT (1.5 ppm).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; may form small amounts of phosgene due to unusual exposure to light in the presence of air; degrades slowly when exposed to air; reacts with chemically active metals, strong caustics, and fuming sulfuric acid; attacks most plastics and rubber; reaction with water can cause appreciable hydrolysis; above 110°C (230°F), hydrolysis and oxidation become rapid; not an inert solvent; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-195.0 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** nonflammable liquid; NFPA rating Health 3, Flammability 0, Reactivity 0; not considered to be a fire hazard; not considered to be an explosion hazard; considered to be a very severe industrial hazard; reacts violently with dinitrogen tetraoxide (N<sub>2</sub>O<sub>4</sub>), 2,4-dinitrophenyl disulfide, and on contact with potassium or sodium; spontaneously flammable chloro- or dichloroacetylene gas is produced when heated in contact with solid potassium hydroxide; will attack some forms of plastics, rubber, and coatings; in the presence of steam, contact with hot iron, aluminum and zinc may cause formation of toxic vapors; incompatible with alkali metals, strong bases and many powdered metals; decomposes on burning under influence of air, moisture and UV light, producing toxic and explosive vapors (such as phosgene, hydrogen chloride, chlorinated solvents, carbon dioxide, and carbon monoxide); in case of fire in the surroundings, all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (cough, wheezing, sore throat, shortness of breath, headache, dizziness, nausea, vomiting, abdominal pain); skin absorption (tremors, restlessness, somnolence, delirium, dizziness, nausea, vomiting); skin contact (dry skin, redness, itching, pain); eye contact (severe irritation, tearing, corneal burns, eye damage); ingestion (irritates gastrointestinal tract, nausea, vomiting, diarrhea, salivation).

**FIRST AID:** wash eyes immediately with large amounts of water; on frostbite, wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; in case of ingestion, induce vomiting immediately and call a physician.

**HUMAN TOXICITY DATA:** oral-human TDLo 30mg/kg; toxic effect: central nervous system; inhalation-human TCLo 100mg/m<sup>3</sup>/30M; toxic effect: central nervous system.

**ACUTE HEALTH RISKS:** strong irritation of mucous membranes and upper respiratory tract; irritation of nose and throat; lacrimation; salivation; cough; dizziness; headache; restlessness; nausea; vomiting; narcosis; abdominal pain; diarrhea; depression of central nervous system; tremors; may progress to a more serious illness with jaundice, liver tenderness, lung edema, etc.; possible convulsions and coma preceding death.

**CHRONIC HEALTH RISKS:** may result in liver impairment, including jaundice, cirrhosis and an enlarged liver; may have effects on the central nervous system, including headaches, dizziness, tremors, somnolence, delirium, changes in the brain and peripheral nerves; chronic exposure may also affect blood-forming organs, resulting in hemolysis of red blood cells; can produce fatty degeneration of the kidneys and heart; liquid may cause defatting of skin and possible dermatitis; may possibly alter genetic material; based on testing in animals, overexposure may cause reproductive disorders; possible human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 ppm (6.9 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 5 ppm (35 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 1 ppm (7 mg/m<sup>3</sup>)(skin) reduce to lowest level; IDLH 100 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; use a system of local exhaust ventilation to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers or absorb with an inert material (e.g., dry earth, sand, vermiculite); flush remaining spill with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of in accordance with federal, state, and local regulations; store in a cool, dry area; use only with adequate ventilation; keep in tightly closed containers; protect against physical damage; isolate from incompatible substances; separate from food and feedstuffs.

**REGULATORY INFORMATION:** CA2; S3; S40; R2; R3; R4; R5; R7; R8; U waste # (U209); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf3; CW4; CW5; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in cleaning and degreasing of metals; used in the manufacture of paint removers, lacquers, varnishes, and varnish removers; used as a solvent in preparation of adhesives; useful as a chemical intermediate in manufacture of trichloroethylene and tetrachloroethylene; use in refining of waxes and resins; note: use has been forbidden or restricted in certain countries.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 13; 14; 16; 19.

### TETRACHLORONAPHTHALENE (C<sub>10</sub>H<sub>4</sub>Cl<sub>4</sub>, 265.94)

**CAS/DOT IDENTIFICATION #:** 1335-88-2/none

**SYNONYMS:** halowax<sup>®</sup>, nibren wax, seekay wax, 1,2,3,4-tetrachloro-1,2,3,4-tetrahydronaphthalene.

**PHYSICAL PROPERTIES:** colorless to pale-yellow, waxy solid; sweet smelling odor; insoluble in water; MP (182°C, 360°F); BP (311.5 - 360°C, 592.7 - 680°F); DN/SG (1.59-1.65); VD (9.2); VP (1 x 10<sup>-6</sup> mmHg at 25°C (est)).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; does not react with water; can react vigorously with strong oxidizers; FP (210°C, 410°F); LFL/UFL (no data found); AT (none to boiling point).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; tetrachloronaphthalene, itself, does not burn; NFPA rating (not rated); contact with strong oxidizers (such as chlorine, bromine and fluorine) may cause fires and explosion; hazardous decomposition products (such as

hydrogen chloride, phosgene and carbon monoxide) may be released in a fire; use carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, vertigo, irritates eyes, skin and respiratory system); skin absorption (fatigue, vertigo, anorexia); skin contact (acne-like skin rash, makes skin sunburn more easily); ingestion (liver injury, jaundice, dark urine).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, administer oxygen; if breathing has stopped, perform mouth-to-mouth resuscitation; if this chemical has been swallowed, seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** headache, vertigo (an illusion of movement); irritation of skin, causing a rash or burning feeling; can also make the skin sunburn more easily; irritation of eyes; anorexia.

**CHRONIC HEALTH RISKS:** repeated exposure can lead to an acne-form dermatitis; exposure can cause severe liver damage, resulting in such effects as yellow jaundice, dark urine, and fatigue.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 mg/m<sup>3</sup>; OSHA PEL TWA 2 mg/m<sup>3</sup> (skin); NIOSH REL TWA 2 mg/m<sup>3</sup>; IDLH (unknown).

**PERSONAL PROTECTION:** wear appropriate personal protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use splash-proof safety goggles where there is any possibility of molten tetrachloronaphthalene contacting the eyes; wear dust-proof safety goggles and face shield when working with powders or dust; enclose operations and/or provide local exhaust ventilation at the site of chemical release; appropriate respirators are needed in areas where exposures are above 2 mg/m<sup>3</sup>; if the possibility of 20 mg/m<sup>3</sup> exists, use self-contained breathing apparatus operated in positive pressure mode; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; cautiously collect solid material and deposit in sealed containers; absorb liquids containing tetrachloronaphthalene with inert materials (such as dry earth, sand, and vermiculite).

**DISPOSAL AND STORAGE METHODS:** may be disposed of in a secured, sanitary landfill; recommended method of disposal is incineration, preferably after mixing with another combustible fuel; incinerator should be equipped with an acid scrubber, necessary to remove the halo acids produced; should be stored in tightly closed containers in a cool, well-ventilated place, away from areas of high fire hazard and out of direct rays of sun; avoid contact with strong oxidizers, since violent reactions occur.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (none).

**OTHER COMMENTS:** used during manufacture of electrical insulation materials, as a component of resins or polymers for coating or impregnating textiles, wood, and paper to impart water proofness, and as an additive for cutting oils and lubricants, formerly used a pesticide.

**KEY REFERENCES:** 4; 5; 6; 7; 14; 15; 16.

**TETRAETHYL LEAD (Pb(C<sub>2</sub>H<sub>5</sub>)<sub>4</sub>, 323.47)**

**CAS/DOT IDENTIFICATION #:** 78-00-2/UN1649

**SYNONYMS:** lead, tetraethyl, tel, tetraethylplumbane, tetraethylplumbium.

**PHYSICAL PROPERTIES :** colorless, oily liquid; sometime dyed red, orange, or blue; burns with an orange-colored flame with green margin; pleasant, sweet odor; soluble in benzene, ethanol, diethyl ether, gasoline, and petroleum ether; lipid soluble; practically insoluble in water; MP (125-150°C, 257-302°F); BP (198-202°C, 388.4-395.6°F); DN (1.65 g/mL at 20°C); LSG (1.65); ST (28.5 dynes/cm at 25°C); VS (0.864 mPa-s at 20°C); CP (307.4 J/K-mol liquid at 25°C); HV (12,959.7 g/cal); VP (0.2 mmHg at 20°C, 1 mmHg at 38.4°C).

**CHEMICAL PROPERTIES:** combustible liquid; some solvent action on rubber; decomposes slowly at room temperature and more rapidly at elevated temperatures; exposure to sunlight decomposes to toxic triethyl lead; reacts with strong oxidizers, sulfuryl chloride, rust and potassium permanganate; FP (93.3°C, 200°F); LFL/UFL (1.8%, NA); HC (-7,870 Btu/lb, -4,380 cal/g,  $-183 \times 10^5$  J/kg); HF (52.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 3, Flammability 2, Reactivity 3; poisonous gases are produced in fire; vapor may explode if ignited in enclosed area; containers may explode in fire; prolonged exposure to fire or heat can cause an explosion and cause cylinders to rupture violently and rocket; can react vigorously with oxidizing materials; explosive decomposition may occur after being exposed to air for several days; forms poisonous triethyl lead when exposed to sunlight or allowed to evaporate; combustion by-products include carbon dioxide, water and toxic fumes of lead; use water spray, dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (insomnia, excitability, delirium, coma, death); skin absorption (weakness, anxiety, disorientation, hallucinations, psychosis, mania, convulsions); contact (hypotension, hypothermia, eye irritation); ingestion (pallor, nausea, weight loss, increased urinary output).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin immediately with kerosene or similar petroleum distillate followed by soap and water; provide oxygen or respiratory support; if ingested, induce vomiting.

**HUMAN TOXICITY DATA:** inhalation-human TLo 1749 mg/m<sup>3</sup>/30M; toxic effect: nose, eye, gastrointestinal tract; unreported-man LDLo 1470 µg/kg.

**ACUTE HEALTH RISKS:** eye irritation; insomnia; weakness; anxiety; tremor; hypotension; hypothermia; pallor; nausea; weight loss; disorientation; hallucinations; psychosis; mania; convulsions; hyper-reflexia; spasticity; bradycardia; increased urinary output of lead; coma; death.

**CHRONIC HEALTH RISKS:** teratogenic and reproductive effects; may alter genetic material; central nervous system effects; anorexia; may have carcinogenic effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg(Pb)/m<sup>3</sup>(skin); OSHA PEL TWA 0.075 mg(Pb)/m<sup>3</sup>(skin); NIOSH REL TWA 0.75 mg(Pb)m<sup>3</sup>(skin); IDLH 40mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear rubber overclothing or white or light colored clothing; wear neoprene coated, liquid proof gloves; rubber shoes or boots are recommended; wear self-contained breathing apparatus and chemical safety goggles.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; flood discharge area with water but not into spaces such as sewers or water sources; tetraethyl lead may be removed

from wastewater with cellulose acetate semi-permeable membrane filtration; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** pour onto vermiculite, sodium bicarbonate, or a sand/soda ash mixture; burn in closed incinerator equipped with afterburner; dissolve in flammable solvent and spray in incinerator equipped with afterburner and alkali scrubber; store in a cool, dry location with adequate ventilation; keep away from sparks, flames, and other sources of ignition.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 10 lbs. (4.54 kg); CAL; DOT hazard class/division (6.1); labels (poison, flammable liquid).

**OTHER COMMENTS:** used as a gasoline additive to prevent knocking in motors (has been largely replaced by methyl-tert-butyl ether); used in the synthesis of ethylmercury compounds; used as a chemical intermediate for mixed alkyl leads.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 11; 12; 14.

## TETRAHYDROFURAN (C<sub>4</sub>H<sub>8</sub>O, 72.12)

**CAS/DOT IDENTIFICATION #:** 109-99-9/UN2056

**SYNONYMS:** butylene oxide, cyclotetramethylene oxide, diethylene oxide, 1,4-epoxybutane, hydrofuran, tetramethylene oxide.

**PHYSICAL PROPERTIES :** colorless, mobile liquid; ether-like odor; pungent taste; soluble in acetone and benzene; miscible with alcohols, ketones, esters, ethers, and hydrocarbons; miscible with water; MP (-108°C, -163°F); BP (66°C, 151°F); DN (0.8892 g/mL at 20°C); LSG (0.89); ST (28 dynes/cm at 20°C); VS (0.456 mPa-s at 25°C); CP (124.0 J/K-mol liquid at 25°C); HV (180 Btu/lb, 98 cal/g, 4.1 x 10<sup>5</sup> J/kg); VD (2.5); VP (114 mmHg at 15°C); OT (20-50 ppm).

**CHEMICAL PROPERTIES:** flammable liquid; hazardous polymerization may occur; may form organic peroxides upon prolonged storage in the presence of air; will attack some forms of plastics, rubber and coatings; can react with strong oxidizers and lithium-aluminum alloys; FP (-14°C, 6°F); LFL/UFL (2.0%, 11.8%); AT (321°C, 610°F); HC (-14,990 Btu/lb, -8330 cal/g, -348.8 x 10<sup>5</sup> J/kg); HF (-216.2 kJ/mol liquid at 25°C); H<sub>f</sub>(8.54 kJ/mol at 164.76K).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 2, Flammability 3, Reactivity 1; flashback along vapor trail may occur; vapor may explode if ignited in enclosed area; very dangerous fire hazard; forms thermally explosive peroxides on exposure to air; must always be tested for peroxides prior to distillation; peroxide inhibitor in tetrahydrofuran may be depleted by caustic alkalies, resulting in an explosion; reacts explosively with potassium hydroxide, sodium aluminum hydride, sodium hydroxide, and sodium tetrahydroaluminate; forms an explosive product upon reaction with 2-aminophenol and potassium dioxide; reacts with borane or lithium tetrahydroaluminate to form explosive hydrogen gas; reacts violently with metal halides; vigorous reaction with bromine, oxidizing materials, and calcium hydride and heat; closed containers may rupture violently when heated; decomposition emits irritating fumes and vapors; use water spray, dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, headache, dizziness, anesthesia, irritates eyes, nose and throat); contact (skin irritation, defatting of skin, eye irritation).

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**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 25,000 ppm; toxic effect: central nervous system.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory tract; nausea; dizziness; headache; narcosis; anesthesia; irritant to mucous membranes.

**CHRONIC HEALTH RISKS:** kidney damage; liver injury; central nervous system depression; defatting of skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 200 ppm; ACGIH TLV STEL 250ppm; OSHA PEL TWA 200 ppm (590 mg/m<sup>3</sup>); OSHA PEL STEL 250 ppm; NIOSH REL TWA 200 ppm (590mg/m<sup>3</sup>); NIOSH REL STEL 250 ppm (735 mg/m<sup>3</sup>); IDLH 2000 ppm

**PERSONAL PROTECTION:** wear self-contained breathing apparatus and splash-proof safety goggles; wear full protective clothing (boots, gloves, sleeves, aprons, etc.).

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; flush spill with large amounts of water and dilute spills to nonflammable mixtures; absorb small quantities on paper towels and evaporate in a fume hood; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible in noncombustible materials such as dry earth or sand and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; outside storage is preferred; inside storage should be in a standard flammable liquids storage room or cabinet; store away from heat, oxidizing materials and sunlight.

**REGULATORY INFORMATION:** S3; R6; U waste # (U213); Reportable Quantity (RQ): 1000 lbs. (454 kg); Sfl; T30-e10; T120-d10; T799-5000; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a solvent for high polymers, especially polyvinyl chloride; used as a solvent for production of tetraethyl and tetramethyl lead; an agent in liquid membrane electrode manufacturing ; may be used as a reaction medium for Grignard and metal hydride reactions; used as a solvent in the preparation of printing inks, adhesives, lacquers, and other coatings; used as a Grignard reagent in synthesis of motor fuels, vitamins, hormones, pharmaceuticals, synthetic perfumes, and organometallic compounds; used in the synthesis of butylrolactone, succinic acid, and 1,4-butanediol diacetate; may be used under Federal Food, Drug and Cosmetic Act for fabrication of articles for packaging, transporting, or storing of foods if residual amount does not exceed 1.5% of the film.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 9; 10; 11; 12; 14.

### TETRAMETHYL LEAD (C<sub>4</sub>H<sub>12</sub>Pb, 267.35)

**CAS/DOT IDENTIFICATION #:** 75-74-1/UN1649 (motor fuel antiknock mixture).

**SYNONYMS:** lead tetramethyl, motor fuel anti-knock compound, tetramethylplumbane, tml.

**PHYSICAL PROPERTIES :** colorless liquid (unless dyed red, orange, or blue); slight musty odor; insoluble in water; slightly soluble in benzene, alcohol, and petroleum ether; vapor is heavier than air; MP (-27.5°C, -17.5°F); BP (110°C, 230°F at 760 mmHg); DN (1.995

g/mL); LSG (2.0 at 20°C); VD (6.5); REL DN vapor/air mixture (1.23 at 20°C); VP (22 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; temperatures above 100°C (212°F) cause decomposition and development of pressure; will attack some forms of plastics, rubber, and coatings; can react vigorously with oxidizing materials; reacts with strong acids; FP (38°C, 100°F); LFL/UFL (1.8%, unknown); AT (unknown); HF (97.9 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid and vapor; very dangerous fire hazard; NFPA rating Health 3, Flammability 3, Reactivity 3; moderately explosive in form of vapor; explosive vapor-air mixtures may be formed above 38°C (100°F) may explode on heating above 90°C (194°F); contact with strong oxidizers, such as sulfuryl chloride or potassium permanganate, may cause fires and explosions; reacts explosively with tetrachlorotrifluoromethyl phosphorane; reacts violently with nitric acid; decomposes on burning producing toxic and flammable gases including lead, oxides of lead, and carbon monoxide; use water spray, foam, dry chemical or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (convulsive seizures, headache, dizziness, nausea, loss of consciousness); skin absorption (difficulty in sleeping, bad dreams, restlessness, hallucination, anxiety, mania, loss of appetite); ingestion (abdominal pain, burning sensation, diarrhea, dullness).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; if not breathing, provide respiratory support; in case of ingestion, rinse mouth; induce vomiting and get immediate medical attention..

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** convulsions; dizziness; headache; nausea; abdominal pain; diarrhea; burning sensation; hallucinations; dullness; insomnia; bad dreams; anxiety; restlessness; poor appetite; delirium; violent behavior; hypotension; unconsciousness; may cause effects on central nervous system, resulting in encephalopathy; may result in death.

**CHRONIC HEALTH RISKS:** fetal damage may occur from exposure of the mother to tetramethyl lead; damage to kidneys; may cause effects on cardiovascular system and central nervous system.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.15 mg(Pb)/m<sup>3</sup>; OSHA PEL TWA 0.75 mg(Pb)/m<sup>3</sup>(skin); NIOSH REL TWA 0.75 mg(Pb)/m<sup>3</sup> (skin); IDLH 40 mg(Pb)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious clothing, including boots, gloves, lab coat, apron or coveralls; use splash-proof safety goggles; above 38°C, use a closed system of local exhaust ventilation and explosion-proof electrical equipment; use positive pressure self-contained breathing apparatus in high vapor concentrations; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** evacuate danger area; ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers; absorb remaining liquid with noncombustible materials (e.g., dry earth, sand, vermiculite), and remove to a safe place; flush spill area with large amounts of water but not into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; may be disposed of by atomizing in a suitable combustion chamber equipped with afterburner and scrubbing device; store in a cool, dry location; maintain adequate ventilation; keep in the dark; separate from strong oxidants, strong acids, food and feed-stuffs.

**REGULATORY INFORMATION:** Sf2; A1; A5; CAL.

**OTHER COMMENTS:** main usage is in anti-knock additives for gasoline; commercial products are impure, dyed red, orange or blue, with added stabilizer (1,2-dichloroethane, toluene); symptoms of encephalopathy do not become manifest until a delayed period of time.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 14; 16.

### **TETRAMETHYL SUCCINONITRILE (C<sub>8</sub>H<sub>12</sub>N<sub>2</sub>, 136.22)**

**CAS/DOT IDENTIFICATION #:** 3333-52-6/none

**SYNONYMS:** tetramethylbutanedinitrile, tetramethylsuccinic acid dinitrile, tetramethylsuccinodinitrile, TMSN.

**PHYSICAL PROPERTIES :** colorless solid; crystallizes in plates; almost odorless; insoluble in water; MP (170°C, 338°F); BP (sublimes); DN (1.07 g/cm<sup>3</sup>); SG (1.07); VD (4.7); VP (no information found).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; substance is a weak acid; can react with strong oxidants; FP (unknown); LFL/UFL (unknown); AT (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating (NA); reacts with strong oxidants causing fire and explosion hazard; decomposes on heating producing toxic fumes of hydrogen cyanide and oxides of nitrogen; use water spray, powder, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, convulsions, nausea, vomiting, unconsciousness); skin absorption (liver and kidney damage); ingestion (gastrointestinal effects).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air and provide oxygen; if not breathing, provide respiratory support; if swallowed, induce vomiting and get medical attention.

**HUMAN TOXICITY DATA:** no data available on the toxicological effects of this substance on human health.

**ACUTE HEALTH RISKS:** headache, dizziness; nausea; vomiting; convulsions; unconsciousness; effects on central nervous system; gastrointestinal effects; coma; death at high concentrations.

**CHRONIC HEALTH RISKS:** kidney damage; injury to the liver; targets central nervous system, liver, kidneys, and gastrointestinal tract.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm (2.8 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 0.5 ppm (3 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 0.5 ppm (3 mg/m<sup>3</sup>)(skin); IDLH 5 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls; use chemical safety goggles and/or a full face shield where dusting or splashing is possible; a closed system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use positive pressure self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into dry container and cover; remove to a safe place; flush spill area with water.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry location; keep in a well-ventilated room; separate from strong oxidants.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a blowing agent for vinyl foam production; a dose of about 25mg/kg of body weight is reported to be fatal in humans; note: tetramethyl succinonitrile forms cyanide in the body.

**KEY REFERENCES:** 4; 5; 6; 7; 14.

### **TETRANITROMETHANE (C(NO<sub>2</sub>)<sub>4</sub>, 196.05)**

**CAS/DOT IDENTIFICATION #:** 509-14-8/UN1510

**SYNONYMS:** nci - C55947, rca waste number P112, tetan, tnm.

**PHYSICAL PROPERTIES:** pale yellow liquid or colorless, oily fluid; exists as a solid below 57°F (13.9°C), acrid, biting odor; sinks in water; miscible with alcohol and ether; freely soluble in alcoholic potassium hydroxide; insoluble in water; MP (13.8°C, 56.8°F); BP (126°C, 259°F at 760 mmHg); DN (1.6229 g/mL at 20°C); LSG (1.62 at 20°C); VS (1.76 cP at 20°C); HV(188 Btu/lb, 104 cal/g, 4.4 x 10<sup>5</sup>J/kg); VD (0.8); VP (8.42 mmHg at 25°C, 10 mmHg at 22.7°C); OT (not available)

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; a powerful oxidizer; sensitive, but weak, explosive when pure; can react vigorously with oxidizing materials; incompatible with finely divided metals, iron and iron salts, copper, brass, zinc or rubber; no reaction with water; FP (>110°C, >230°F); LFL/UFL (unknown); AT (unknown); HC (data not available); IR (1.4384 at 20°C); HLC (2.55 x 10<sup>-5</sup> atm-m<sup>3</sup>/mole (calc)).

**EXPLOSION and FIRE CONCERNS:** combustible liquid, but difficult to ignite; very dangerous fire hazard; NFPA rating (data not available); weak but highly sensitive explosive; highly explosive in presence of impurities and aromatic hydrocarbons; forms explosive mixtures with aluminum, aromatic nitro compounds, hydrocarbons, and p-nitrotoluene; may explode during distillation; severe explosion hazard when shocked or subjected to elevated temperatures; can form very explosive mixtures with oxygen-deficient explosives; mixtures with cotton or toluene may be explosive upon ignition; combustible material wet with tetranitromethane may be highly explosive; attacks iron, copper, brass, zinc, some forms of plastic, rubber, and coatings; heating to decomposition emits highly toxic fumes of oxides of nitrogen; use carbon dioxide, dry chemical, foam, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (dizziness, headache, chest pain, breathing difficulty, bluish discoloration of skin, irritates eyes, nose, throat and mucous membranes); contact (conjunctivitis, tearing, mild skin burns); ingestion (methemoglobinemia, bronchopneumonia, damage to liver and kidneys, heart damage).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, give oxygen; administer artificial respiration if breathing has stopped; if this chemical has been swallowed, seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure; lowest lethal human dose (LDLo) by inhalation exposure is about 500 mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes and mucous membranes; respiratory tract irritation; dyspnea; bronchopneumonia; pulmonary edema; irritation of the nasal mucosa and rhinorrhea; irritation of the throat; conjunctivitis; can induce methemoglobinemia in humans, which may lead to cyanosis; central nervous system depressant; esophageal or gastrointestinal tract irritation or burns may develop; fatty degeneration of the liver and kidneys; human fatalities have occurred from acute exposure.

**CHRONIC HEALTH RISKS:** headache and weakness can occur with chronic vapor exposure; other chronic signs and symptoms include pneumonia, respiratory distress, heart damage and unspecified central nervous system effects; mutation data has been reported, based on animal testing; tetranitromethane is an experimental animal carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.005 ppm (0.04 mg/m<sup>3</sup>); OSHA PEL TWA 1 ppm (8 mg/m<sup>3</sup>); NIOSH REL TWA 1 ppm (8 mg/m<sup>3</sup>); IDLH 4 ppm.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear chemical safety goggles; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in high vapor concentrations; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to reduce vapors or divert vapor cloud drift; absorb liquid spills with inert materials, such as dry earth, sand, or vermiculite; keep combustibles (e.g. wood, paper, oil, etc.) away from spilled material; flush area with flooding quantities of water but not into confined spaces such as sewers due to possibility of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** may be disposed of by absorbing in dry earth, sand, or vermiculite, and placed in a secured, sanitary landfill; this chemical may also be disposed of by liquid injection incineration at a temperature range of 650 to 1,600°C and a residence time of 0.1 to 2 seconds, or by rotary kiln incineration at a temperature range of 820 to 1,600°C and residence times of seconds for liquids and gases, and hours for solids; fluidized bed incineration at a temperature range of 450 to 980°C and residence times of seconds for liquids and gases and longer for solids may also be employed as a possible method of disposal; store in a cool, dry location; use only with adequate ventilation; separate from incompatibles; keep away from combustibles, such as wood, paper, oil, etc.

**REGULATORY INFORMATION:** R4; P waste # (P112); Reportable Quantity (RQ): 10 lbs (4.54 kg); Sfl: Sf2; A1, CAL; DOT hazard class/division (5.1); label (oxidizer, poison)

**OTHER COMMENTS:** used in rocket fuel, as an oxidant or monopropellant; used as a qualitative test for unsaturated compounds (i.e., a reagent for detecting the presence of double bonds in organic compounds); used as a diesel fuel booster (i.e., increases cetane number of diesel fuels); utilized as an ingredient in manufacture of liquid explosives.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 15; 16.

### **TETRYL (C<sub>7</sub>H<sub>5</sub>N<sub>5</sub>O<sub>8</sub>, 287.17)**

**CAS/DOT IDENTIFICATION #:** 479-45-8/UN0208

**SYNONYMS:** N-methyl-N,2,4,6-tetranitroaniline, nitramine, picrylmethylnitramine, picrylnitromethylamine, 2,4,6-tetryl, 2,4,6-trinitrophenyl-N-methylnitramine.

**PHYSICAL PROPERTIES:** colorless to light-yellow, crystalline solid; odorless; not soluble in water; soluble in alcohol, benzene, ether, and glacial acetic acid; negligible solubility in ethanol; MP (130-132°C, 266-270°F); BP (180-190°C, 356-374°F)(explodes); DN (1.57 g/cm<sup>3</sup> at 19°C); SG (1.57); VD (NA); VP (< 1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; a very powerful oxidant; can react with some oxidants; FP (explodes in air at 187°C or 369°F); LFL/UFL (unknown); AT (unknown); HC (data not found in literature).

**EXPLOSION and FIRE CONCERNS:** combustible solid; dangerous fire and explosion risk; class A explosive; NFPA rating (not available in the literature); finely dispersed particles form explosive mixtures in air; risk of fire and explosion when shocked or exposed to heat, flame or friction; more highly sensitive to shock and friction than trinitrotoluene (TNT); reacts with some oxidants causing fire and explosion hazard; contact with trioxxygen difluoride will result in an explosion; ignites on contact with hydrazine; decomposes explosively on heating to 187°C (369°F); hazardous decomposition products include carbon monoxide, carbon dioxide, and oxides of nitrogen; water may be used on small fires; combat fire from a sheltered position; do not attempt to extinguish large fires, but instead, consider evacuation and consult an expert.

**HEALTH SYMPTOMS:** inhalation (coughing, headache, sore throat, nosebleeds, insomnia, abdominal pain, diarrhea); skin contact (redness, skin sensitization, yellow stains of skin and hair); ingestion (nausea, diarrhea, headache, sore throat, malaise, fatigue, weakness).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if breathing has stopped provide artificial respiration; in case of ingestion, seek prompt medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory tract; headache; cough; sore throat; epistaxis (nosebleed); insomnia; sneezing; itching; erythema; edema on nasal folds, cheeks and neck; keratitis (inflammation of the cornea); nausea; vomiting; diarrhea; yellow stains of skin and hair; malaise; irritability; lassitude; fatigue; may cause effects on central nervous system.

**CHRONIC HEALTH RISKS:** prolonged contact may cause sensitization dermatitis; repeated or prolonged inhalation exposure may cause asthma; may cause liver and kidney damage; may have effects on the blood, including anemia.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1.5 mg/m<sup>3</sup>; OSHA PEL TWA 1.5 mg/m<sup>3</sup>(skin); NIOSH REL TWA 1.5 mg/m<sup>3</sup>(skin); IDLH 750 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles; enclose operations and/or use local exhaust ventilation at site of chemical release; use explosion-proof electrical equipment and lighting; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or in IDLH conditions; maintain eye wash baths and safety showers in work area; for extra personal protection, use P3 filter respirator for toxic particles.

**SPILL CLEAN-UP:** danger area should be evacuated immediately; it is advisable to consult an expert with regard to proper clean-up procedures.

**DISPOSAL AND STORAGE METHODS:** dispose of as a hazardous waste, in accordance with federal, state and local regulations; store in a cool, dry location; keep in the dark; maintain adequate ventilation; store in tightly closed containers; containers should be bonded and grounded to prevent buildup of electrostatic charges; keep in a separate building protected from shock, friction, or concussion; separate from strong oxidants.

**REGULATORY INFORMATION:** Al; CAL; DOT hazard class/division (explosive 1.1D); label (explosive 1.1D).

**OTHER COMMENTS:** utilized as a detonator for less sensitive high explosives; used as an indicator (colorless at pH 10.8, reddish-brown at pH 13.0)

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

**THALLIUM, SOLUBLE COMPOUNDS (as TI)** (Soluble thallium compounds have variable molecular formulas. The molecular formula for thallium is Tl. The molecular formula for thallium acetate is C<sub>2</sub>H<sub>3</sub>O<sub>2</sub>Tl. The molecular formula for thallium iodide is ITl. Soluble thallium compounds have variable formula weights. The formula weight for thallium 204.37. The formula weights for thallium acetate and thallium iodide are 263.42 and 331.27 respectively.)

**CAS/DOT IDENTIFICATION #:** Soluble thallium compounds have variable CAS #s. The CAS # for thallium is 7440-28-0. The DOT identification number for soluble thallium compounds is UN1707.

**SYNONYMS:** Synonyms vary depending upon the specific soluble thallium compound. (thallium acetate) thallium (I) acetate, thallium monoacetate, thallos acetate. (thallium iodide) thallium (I) iodide, thallium monoiodide, thallos iodide

**PHYSICAL PROPERTIES :** Properties vary depending upon the specific soluble thallium compound. (thallium acetate) silk-white crystals or hygroscopic, colorless monoclinic crystals from ethanol; soluble in water and alcohol; MP (131°C, 268°F); DN (3.68 g/cm<sup>3</sup>). (thallium iodide) yellow, crystalline powder; metallic at high pressures; becomes gray on exposure to light; becomes red at 170°C (338°F); almost insoluble in water; soluble in potassium iodide solution and aqua regia; insoluble in alcohol; MP (440°C, 824°F); BP (824°C, 1515°F); DN (7.09 g/cm<sup>3</sup>); SG (7.1); HV (104.7 kJ/mol at 1097K); VD (NA); VP (unknown).

**CHEMICAL PROPERTIES:** Properties vary depending upon the specific soluble thallium compound. (thallium acetate) hygroscopic; light sensitive. (thallium iodide) stable to dilute hydrochloric acid and sulfuric acid; decomposed by nitric acid; photosensitive; HF (-123.8 kJ/mol crystal at 25°C); H<sub>f</sub> (13.1 kJ/mol at 713K).

**EXPLOSION and FIRE CONCERNS:** Incompatibilities and reactivities vary depending upon the specific soluble thallium compound; most thallium compounds are flammable in the form of dust when exposed to heat or flame; reacts violently with other halogens at room temperature; forms toxic compounds on contact with steam or moist air; emits toxic fumes of Tl in a fire; all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (loss of hair on the body and head, severe pains in the legs and loins, chest pain, abdominal pain, nausea, vomiting, diarrhea, dry skin); skin contact (industrial poisoning has been reported to cause hair discoloration, which later falls out); ingestion (loss of vision, polyneuritis, psychic disturbances, delirium, convulsions, respiratory paralysis, angina-like pains, coma).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; rinse and wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, give artificial respiration; if ingested, rinse mouth and give a slurry of activated charcoal in water to drink; induce vomiting and get medical attention.

**HUMAN TOXICITY DATA:** Toxicological data reported in humans varies according to the specific soluble thallium compound. (thallium acetate) oral-human LDLo 12 mg/kg; unreported-human LDLo 26 mg/kg; unreported-child LDLo 8mg/kg. (thallium iodide) oral-man TDLo 286 mg/kg; toxic effects: behavioral effects.

**ACUTE HEALTH RISKS:** abdominal pain; nausea; vomiting; diarrhea; loss of hair (alopecia); pain in legs and chest; dry skin; loss of vision; polyneuritis; psychic disturbances; delirium; convulsions; cardiac disturbances; respiratory paralysis; optic nerve atrophy; encephalopathy; liver and kidney damage; swelling of the feet and legs; insomnia; partial paralysis of the legs with reaction of degeneration; nephritis; wasting; weakness; lymphocytosis; discoloration of hair (which later falls out); joint pain; loss of appetite; fatigue; albuminuria; coma; exposure may result in death.

**CHRONIC HEALTH RISKS:** may have effects on vision, nervous system, skin (hair), heart, and gastrointestinal tract; possibly causes toxic effects upon human reproduction.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA (soluble compounds (as Tl)) 0.1 mg/m<sup>3</sup>(skin); OSHA PEL TWA (soluble compounds (as Tl)) 0.1 mg/m<sup>3</sup>(skin); NIOSH REL TWA (soluble compounds (as Tl)) 0.1 mg/m<sup>3</sup>(skin); IDLH (soluble compounds (as Tl)) 15 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles or eye protection in combination with breathing protection if powder; local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; use self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP:** sweep spilled substance into sealable containers; carefully collect remainder, then remove to a safe place.

**DISPOSAL AND STORAGE METHODS:** whatever cannot be saved for recovery or recycling should be managed in an approved waste disposal facility; dispose of container and

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unused contents in accordance with federal, state, and local requirements; store in a cool, dry, well-ventilated area; storage should be in tightly sealed containers; separate from strong acids, fluorine, other halogens, food and feedstuffs.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** thallium salts are added to a mixture with 97-98% of inert substance and are used as a poison for rats and other rodents; thallium acetate is used in high specific gravity solutions used to separate ore constituents by flotation; thallium iodide may be used as mixed crystals with thallium bromide for infrared-radiation transmitters.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 12; 14.

### 4,4'-THIOBIS(6-tert-BUTYL-m-CRESOL)(C<sub>22</sub>H<sub>30</sub>O<sub>2</sub>S, 358.58)

**CAS/DOT IDENTIFICATION #:** 96-69-5/none

**SYNONYMS:** antioxidant ao, bis (4-hydroxy-5-tert-butyl-2-methylphenyl)sulfide, 4,4'-thiobis(3-methyl-6-tert-butylphenol), 1,1'-thiobis(2-methyl-4-hydroxy-5-tert-butylbenzene).

**PHYSICAL PROPERTIES :** light-gray to tan powder; slight aromatic odor; slightly soluble in water; MP (150°C, 302°F); BP (unknown); DN (1.10 g/cm<sup>3</sup>); SG (1.10); VD (NA); VP (0.0000006 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; no incompatibilities and reactivities have been reported; FP (215.6°C, 420.1°F); LFL/UFL (NA); AT (NA); HC (no information found).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating (not rated); poisonous gases are produced in a fire, including oxides of sulfur; employees must be trained and equipped as stated in OSHA 1910.156, if expected to fight fires.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory system). (Note: this chemical has not been well tested for health effects.)

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, move exposed person to fresh air promptly; other measures are usually not necessary; if this chemical has been swallowed get medical attention immediately.

**HUMAN TOXICITY DATA:** no LD50/LC50 information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes, skin, and respiratory system. (Note: this chemical has not been well tested for health effects.)

**CHRONIC HEALTH RISKS:** repeated overexposure may cause liver damage; mutation data has been reported. (Note: this chemical has not been well tested for health effects.)

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup>; OSHA PEL TWA 15 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg (total dust)/m<sup>3</sup>, 5 mg (respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical resistant gloves, lab coat, apron or coveralls; wear dust-proof safety goggles when working with powders or dust; enclose operations and use local exhaust ventilation at site of chemical release; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; use self-contained breathing apparatus operated in positive pressure mode in high vapor concentrations; maintain eyewash fountains and safety showers in work area.

**SPILL CLEAN-UP:** collect powdered material in a cautious manner and deposit in sealed containers; do not dry sweep; use a vacuum or a wet method to reduce dust during clean-up.

**DISPOSAL AND STORAGE METHODS:** contain and dispose of this chemical as a hazardous waste; dispose of in accordance with federal, state, and local regulations; store in tightly closed containers in a cool, well-ventilated area.

**REGULATORY INFORMATION:** A1; CAL; DOT classification (none).

**OTHER COMMENTS:** This chemical presented limited information with regard to its physical and chemical properties. This chemical has not been well tested for health effects. It is used in making plastics and rubber products; this substance has also been used to protect light-colored rubber from oxidation and non-staining neoprene compounds from oxidation.

**KEY REFERENCES:** 4; 5; 6; 7; 15.

### **THIRAM (C<sub>6</sub>H<sub>12</sub>N<sub>2</sub>S<sub>4</sub>, 240.44)**

**CAS/DOT IDENTIFICATION #:** 137-26-8/UN2771

**SYNONYMS:** bis(dimethylthiocarbamoyl)disulfide, methyl thiram, tetramethylthiuram disulfide, thiuram.

**PHYSICAL PROPERTIES :** colorless to yellow, crystalline solid; commercial products may be dyed blue; characteristic odor; soluble in alcohol, benzene, chloroform, and carbon disulfide; insoluble in water, dilute alkali, and gasoline; MP (155-156°C, 311-313°F); BP (129°C, 264°F at 20mmHg); DN (1.29 g/cm<sup>3</sup> at 20°C); SG (1.29); VD (NA); BP (7.5 x 10<sup>-6</sup> mmHg at 25°C); OT (5mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** combustible solid; non-corrosive in the dry state; loss of strength on prolonged exposure to air, moisture, and heat; decomposes in acidic media; can react with strong oxidizers and oxidizable materials; FP (89°C, 192°F); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating (NA); contact with strong oxidizers may cause fires and explosions; may cause formation of toxic gases such as hydrogen sulfide on contact with strong acids or oxidizable materials; toxic gases and vapor, such as sulfur dioxide, carbon disulfide, and carbon monoxide, may be released in a fire; use carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (respiratory irritation, irritates eyes, nose and throat); ingestion (headache, nausea, vomiting, diarrhea, dyspnea, erythema, pruritis, urticaria, possible paralysis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water immediately and induce vomiting.

**HUMAN TOXICITY DATA:** inhalation-human  $\text{TCLo } 30\mu\text{g}/\text{m}^3/5\text{Y}$ ; toxic effect: pulmonary effects.

**ACUTE HEALTH RISKS:** irritation of eyes, nose, throat, and skin; irritation of mucous membranes; nausea; vomiting; diarrhea; loss of appetites; with ingestion of alcohol: skin redness; hives; flushing of skin; sweating; pulsating headache; nausea; vomiting; diarrhea; dizziness; weakness; difficulty in breathing.

**CHRONIC HEALTH RISKS:** chronic respiratory disease; skin sensitization; eczema on the hands, forearms, and feet; paralysis may occur.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $1\text{mg}/\text{m}^3$ ; OSHA PEL TWA  $5\text{mg}/\text{m}^3$ ; NIOSH REL TWA  $5\text{mg}/\text{m}^3$ ; IDLH  $5\text{mg}/\text{m}^3$ .

**PERSONAL PROTECTION:** rubber gloves, hats, suits, and boots must be worn; use dust- and splash-proof safety goggles; wear self-contained breathing apparatus operated in positive pressure mode; should be mechanically handled in closed systems.

**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper, place in an appropriate container, and cautiously burn in a fume hood; dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber.

**DISPOSAL AND STORAGE METHODS:** prepare packages of thiram in paper or other flammable materials and burn in suitable combustion chamber equipped with appropriate effluent gas cleaning device; dissolve in a flammable solvent, such as alcohol, and burn in incinerator with afterburner and sulfur dioxide scrubber; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers and strong acids.

**REGULATORY INFORMATION:** F1; F3; R4; R6; U waste # (U244); Reportable Quantity (RQ): 10 lbs (4.54kg); Sf1; Sf3; CAL.

**OTHER COMMENTS:** used in the rubber industry as an accelerator and vulcanizing agent; used as a bacteriostat in commercial and surgical soap, antiseptics, sunburn oil and fats; useful as a seed disinfectant.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 16.

**TIN, INORGANIC COMPOUNDS (except oxides, as Sn)** (Inorganic tin compounds have variable molecular formulas. The molecular formula for tin is Sn. Specific inorganic tin compounds are as follows: stannous chloride ( $\text{SnCl}_2$ ), stannic chloride ( $\text{SnCl}_4$ ), and stannous sulfate ( $\text{SnSO}_4$ ). Inorganic tin compounds have variable formula weights. The formula weight for tin is 118.71. The formula weights for stannous chloride, stannic chloride, and stannous sulfate are 189.6, 260.5 and 214.8, respectively.)

**CAS/DOT IDENTIFICATION #:** Inorganic tin compounds have variable CAS #s. The CAS # for tin is 7440-31-5. Tin and inorganic tin compounds do not have a DOT identification.

**SYNONYMS:** Synonyms vary depending upon the specific inorganic tin compound; (stannous chloride) tin (II) chloride, tin dichloride, tin protochloride; (stannic chloride) tin (IV) chloride, tin tetrachloride, tin protochloride; (stannic sulfate) tin (II) sulfate.

**PHYSICAL PROPERTIES :** Physical properties vary depending upon the specific inorganic tin compound. (stannous chloride) white crystalline mass; has a fatty appearance; odorless; soluble in less than its own weight of water; very soluble in dilute or concentrated hydrochloric acid; soluble in ethanol, acetone, ether, methyl acetate, isobutyl alcohol, alkalis, tartaric acid, and methyl ethyl ketone; practically insoluble in xylene, petroleum naphtha, and mineral spirits; MP (247°C, 477°F); BP (605°C, 1121°F at 760 mmHg); DN (3.95 g/cm<sup>3</sup> at 25°C); SG (3.95); HV (86.8 kJ/mol at 896K); VD (not applicable); VP (approximately 0 mmHg at 20°C); (stannic chloride) colorless to yellow, fuming caustic liquid or crystals; acrid odor; converted into a crystalline solid by water; soluble in cold water, alcohol, carbon disulfide, carbon tetrachloride, and benzene; MP (-33°C, -27°F); BP (114°C, 237°F at 760 mmHg); DN (2.232 g/cm<sup>3</sup>) LSG (2.23); CP (165.3 J/K-mol liquid at 25°C); HV (34.9 kJ/mol at 387.30 K); VD (9.0); VP (18 mmHg at 20°C); (stannous sulfate) heavy white or yellowish, orthorhombic crystals; odorless; solute in water and dilute sulfuric acid; MP (300°C, 572°F) BP (decomposes); DN/SG (>1); VD (not applicable); VP (approximately 0 mmHg at 20°C)

**CHEMICAL PROPERTIES:** Chemical properties vary depending upon the specific inorganic tin compound. Metallic tin normally has a protective film of stannic oxide which thickens as the temperature is raised; powder will oxidize, especially in the presence of moisture; stannous chloride absorbs oxygen from the air and is converted into insoluble oxychloride; stannic chloride may be decomposed by hot water, evolving much heat; stannic chloride will attack forms of plastic, rubber, and coatings; water solution of stannous sulfate decomposes rapidly with precipitation of a basic sulfate; (stannous chloride) FP (NA); LFL/UFL (NA); AT (NA); HF (-325.1 kJ/mol crystal at 25°C; Hf (12.8 kJ/mol at 520 K). (stannic chloride) FP (NA); LFL/UFL (NA); AT (NA); HF (-511.3 kJ/mol liquid at 25°C); Hf (9.2 kJ/mol at 240K). (stannous sulfate) FP (NA); LFL/UFL (NA); AT (NA); HF (data not found); Hf (data not found). (tin) AT (dust cloud: 630°C, 116.6°F; dust layer: 430°C, 806°F).

**EXPLOSION and FIRE CONCERNS:** metallic tin is a noncombustible solid, but powdered form may ignite; sufficient concentrations of fine dust dispersed in air and in the presence of an ignition source is a potential dust explosion hazard; stannous chloride reacts violently with hydrogen peroxide, ethylene oxide, hydrazine hydrate, nitrates, sodium, and potassium; if moisture enters containers of stannic chloride, pressure may burst containers; contact of stannic chloride with water, alcohols, amines, ethylene oxide, alkyl nitrates and turpentine may cause fires and explosions; stannous chloride ignites on contact with bromine trifluoride; stannous sulfate decomposes to form toxic sulfur dioxide at temperatures above 360°C (680°F); a vigorous reaction with calcium acetylide and stannous chloride is initiated by flame; stannic chloride liberates hydrochloric acid on contact with moisture or heat; toxic gases and vapors may be released in a fire involving stannous sulfate and tin chlorides; in case of fire involving tin, use dry sand, sodium chloride, graphite or dolomite.

**HEALTH SYMPTOMS:** inhalation (sore throat, irritates eyes, nose and skin); skin contact (may cause mild irritation and redness); eye contact (may cause mechanical irritation); ingestion (large doses may cause nausea, vomiting, diarrhea).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; perform artificial respiration if breathing has stopped; in case of ingestion, give large quantities of water immediately; induce vomiting after water has been swallowed and seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found relating to normal routes of occupational exposure.

## 954 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) CHEMICALS

**ACUTE HEALTH RISKS:** irritation to eyes, nose, throat, and skin; large doses may cause nausea, vomiting, and diarrhea. note: (in general, the toxicity of inorganic tin salts is low).

**CHRONIC HEALTH RISKS:** prolonged inhalation of dust or fume may result in a benign pneumoconiosis; distinctive lung changes with no apparent disability or complications.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $2\text{mg}(\text{Sn})/\text{m}^3$ ; OSHA PEL TWA  $2\text{mg}(\text{Sn})/\text{m}^3$ , NIOSH REL TWA  $2\text{mg}(\text{Sn})/\text{m}^3$ ; IDLH  $100\text{mg}(\text{Sn})/\text{m}^3$ .

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use chemical safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; clean up spills in a manner that does not disperse dust into the air; moisten spill with water in order to reduce airborne dust and prevent scattering; deposit in sealed containers for recovery or disposal; absorb liquid containing inorganic tin compounds with inert materials such as dry earth, sand, or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** inorganic tin compounds may be disposed of in sealed containers in a secured, sanitary landfill; store in a cool, dry area; use only with adequate ventilation; keep in tightly closed containers; protect against physical damage; isolate from any source of heat or ignition.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (stannic chloride) (8); label (corrosive); no transport information found on the literature for the other compounds.

**OTHER COMMENTS:** stannic chloride is used in dyeing silk; use of stannic chloride in the manufacture of blueprint paper, as a perfume stabilizer in soap, in the preparation of lubricating oil additives, in treating glass surfaces, as a bleaching agent for sugar, and as a catalyst in the manufacture of pharmaceuticals; stannous chloride is used in the manufacture of blueprint paper, as an anti-sludge agent in lubricating oils, as a catalyst in organic reactions, as an additive in drilling mud, in silvering of mirrors, and as a food additive; stannous sulfate may be used for use in acidic electroplating baths and in dyeing textiles.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8;14; 16.

**TIN, ORGANIC COMPOUNDS (as Sn)** (Organic tin compounds have variable molecular formulas. The molecular formula for tin is Sn. Specific organic tin compounds are as follows: triphenyltin chloride ( $\text{C}_{18}\text{H}_{15}\text{SnCl}$ ), tetrabutyltin ( $\text{C}_{16}\text{H}_{36}\text{Sn}$ ), and stannous 2-ethylhexoate ( $\text{C}_{16}\text{H}_{30}\text{O}_4\text{Sn}$ ). Organic tin compounds have variable formula weights. The formula weight for tin is 118.71. The formula weights for triphenyltin chloride, tetrabutyltin, and stannous 2-ethylhexoate are 385.5, 347.2 and 404.7, respectively).

**CAS/DOT IDENTIFICATION #:** Organic tin compounds have variable CAS #s. The CAS # for tin is 7440-31-5. Tin and inorganic tin compounds do not have a DOT identification.

**SYNONYMS:** Synonyms vary depending upon the specific organic tin compound. (triphenyltin chloride) aquatin, chlorotriphenyltin, fentin chloride, triphenyl chlorostannane, triphenylchlorotin. (tetrabutyltin) tetra-n-butyltin, tetrabutylstannane. (stannous-2-ethylhexoate) stannous octoate, tin octoate.

**PHYSICAL PROPERTIES :** Physical properties vary depending upon the specific inorganic tin compound. (triphenyltin chloride) white, crystalline solid; characteristic odor; soluble in organic solvents; insoluble in water; MP (106°C, 223°F); BP (240°C, 464°F at 13.5 mmHg); DN/SG (>1); VD (not applicable); VP (<1 mmHg at 20°C). (tetrabutyltin) colorless or slightly yellow, oily liquid; distinct, characteristic odor; soluble in most common organic solvents; insoluble in water; MP (<-70°C, <-94°F); BP (145°C, 293°F at 10 mmHg); DN (1.0572 g/mL at 20°C) LSG (1.06); VD (not applicable); VP (<1 mmHg at 20°C). (stannous-2-ethylhexoate) pale yellow, viscous liquid; characteristic odor; soluble in benzene, toluene, and petroleum ether; insoluble in water and methanol; MP (< -25°C, <-13°F) BP (200°C, 392°F decomposes); DN (1.25 g/mL at 20°C); VD (not applicable); VP (<1 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; organic tin compounds will attack some forms of plastics, rubber, and coatings, stannous-2-ethylhexoate may be hydrolyzed by acids and bases; organic tin compounds can react with strong oxidizers; (triphenyltin chloride) FP (NA); LFL/UFL (NA, probably because too high boiling points); AT (NA); (tetrabutyltin) FP (124°C, 255°F); LFL/UFL (NA, probably because too high boiling points); AT (NA); (stannous-2-ethylhexoate) FP (142°C, 287°F); LFL/UFL (NA, probably because too high boiling points); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; contact with strong oxidizers may cause fires and explosions; toxic gases and vapors, such as carbon monoxide and carbon dioxide, may be released in a fire; triphenyltin chloride will emit toxic fumes of Cl- when heated to decomposition; use water, dry chemical, alcohol foam, and carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, vertigo, cough, focal anesthetic effects, irritates eyes, throat and skin); skin absorption (psychoneurologic disturbances, visual disturbances, effects on central nervous system); contact (lacrimation, conjunctivitis, skin burns, pruritus, urine retention); ingestion (abdominal pain, nausea, vomiting, headache, urinary retention, blood effects, damage to kidneys, may cause injury to the liver).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; perform artificial respiration if breathing has stopped; in case of ingestion, give large quantities of water immediately; induce vomiting after water has been swallowed and seek immediate medical attention.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found relating to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** irritation to eyes, skin and respiratory system; headache, vertigo; sore throat; cough; abdominal pain; vomiting; urinary retention; visual disturbances, including photophobia; transient paralysis; psychic disturbances; chemical skin burns; lacrimation; conjunctivitis.

**CHRONIC HEALTH RISKS:** persistent headache; diminished visual acuity; focal anesthesia; permanent paralysis with incontinence; some organic tin compounds may produce cerebral edema, while others cause hepatic necrosis; organic tin compounds cause hemolysis in animals; may produce neurological damage and eye abnormalities such as glaucoma; organic tin compounds are defatting agents and can cause dermatitis on prolonged exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1mg(Sn)/m<sup>3</sup>(skin); ACGIH TLV STEL 0.2 mg (Sn)/m<sup>3</sup> (skin); OSHA PEL TWA 0.1mg/m<sup>3</sup>, NIOSH REL TWA 0.1mg/m<sup>3</sup> (skin); IDLH 25mg(Sn)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear impervious protective clothing, including boots, chemical-resistant gloves, lab coat, apron or coveralls; use dust- and splash-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure limit is exceeded; use positive pressure self-contained breathing apparatus where the exposure levels are not known; maintain eye wash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; clean up spills in a manner that does not disperse dust into the air; moisten spill with water in order to reduce airborne dust and prevent scattering; deposit in sealed containers for recovery or disposal; absorb liquid containing organic tin compounds with inert materials such as dry earth, sand, or vermiculite; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** organic tin compounds may be disposed of in sealed containers in a secured, sanitary landfill; store in a cool, dry area; use only with adequate ventilation; keep in tightly closed containers; protect against physical damage; isolate from any source of heat or ignition.

**REGULATORY INFORMATION:** A1; no transport information found in literature.

**OTHER COMMENTS:** used as a catalyst in organic and inorganic synthesis in oxidation, hydrogenation, halogenation, condensation, esterification, and polymerization; used as a stabilizing agent against degradation effects to light, heat, and oxygen on polyvinyl chloride, chlorinated polyethylenes, neoprene, silicones, vinyl copolymers, and polyamides; utilized in the manufacture of insecticides, fungicides, bactericides, and rodent repellants; has also been used as veterinary medicine and as a fuel additive and lubricant.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14; 16.

### TITANIUM DIOXIDE (TiO<sub>2</sub>, 79.90)

**CAS/DOT IDENTIFICATION #:** 13463-67-7/none

**SYNONYMS:** rutile, titanium oxide, titanium (IV) oxide, titanium peroxide.

**PHYSICAL PROPERTIES :** white amorphous powder or white solid; odorless; has the greatest covering power of all inorganic white pigments; soluble in hot concentrated sulfuric acid and hydrogen fluoride; insoluble in water, hydrochloric acid, nitric acid, dilute sulfuric acid, and alcohol; very high refractive index; MP (1855°C, 3371°F); BP (2500-3000°C, 4532-5432°F); ND (3.9-4.3 g/cm<sup>3</sup>); SG (3.9-4.3); CP (55.0 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; prolonged heating will produce a less soluble material; fusion with potassium bisulfate, alkali hydroxides or carbonates will yield alkali titanates; loses oxygen in air to form TiO<sub>1.985</sub> which melts at 18°C (64.4°F); FP (NA); LFL/UFL (NA); AT (NA); HF (-944.0 kJ/mol crystal at 25°C).

**EXPLOSION and FIRE CONCERNS:** noncombustible solid; not expected to be a fire hazard; NFPA rating (NA); reacts violently or incandescently with metals at high temperatures (e.g., aluminum, magnesium, calcium, sodium, potassium, zinc, lithium); no other information found concerning explosion data; no information found concerning hazardous decomposition products; in case of fire in the surroundings, all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (slight change in lungs may occur, irritates upper respiratory tract, irritates mucous membranes); skin contact (irritation, dermatitis); eye contact (irritation); ingestion (no potential health affects identified).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; rinse and then wash affected areas of skin with plenty of soap and water; if breathing is difficult, remove to fresh air; administer artificial respiration if indicated; if large amounts were swallowed, rinse mouth and drink large amounts of water; seek immediate medical advice.

**HUMAN TOXICITY DATA:** skin-human 300µg/3D intermittent; toxic effects: mild irritant effects.

**ACUTE HEALTH RISKS:** irritation of upper respiratory tract; irritation of mucous membranes; slight lung fibrosis; skin irritation; dermatitis.

**CHRONIC HEALTH RISKS:** no information found.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg/m<sup>3</sup> (total dust containing no asbestos and <1% free silica); OSHA PEL TWA 15 mg/m<sup>3</sup>; NIOSH REL TWA (potential occupational carcinogen); IDLH 5000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear clean body-coverings and protective gloves; use dust- and splash-proof safety goggles; a system of local exhaust ventilation is recommended to control emissions at the sources and to prevent dispersion into general work area; use a full-facepiece positive pressure, self-contained breathing apparatus in instances where the exposure levels are not known; for extra personal protection, a P1 filter respirator for inert particles may be employed; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; sweep spilled substance into containers; collect remaining material, then remove to a safe place; liquid containing titanium dioxide should be absorbed in an inert material (e.g., dry earth, sand, vermiculite).

**DISPOSAL AND STORAGE METHODS:** absorb in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of container and unused contents in accordance with federal, state and local regulations; suitable for any general chemical storage area; keep containers tightly close; all warnings and precautions listed for this product should be observed because empty containers of this material may be hazardous since they retain product residues.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a white pigment in exterior house paints, interior air-dry and baked enamels and lacquers, inks and plastics, in water paints, leather finishes, shoe whiteners, and ceramics; rutile sand is suitable for coating welding rod materials; rutile-like pigments are also useful as opacifying agents; other uses include the manufacturer of cosmetics, food color additives, and synthetic diamonds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14; 16.

## **TOLUENE (C<sub>6</sub>H<sub>5</sub>CH<sub>3</sub>, 92.15)**

**CAS/DOT IDENTIFICATION #:** 108-88-3/UN1294

**SYNONYMS:** methylbenzene, methylbenzol, phenylmethane, toluol.

**PHYSICAL PROPERTIES:** colorless liquid; pungent, benzene-like odor; miscible with alcohol, chloroform, ether, acetone, acetic acid, and carbon disulfide; soluble in alcohol, ether, acetate, benzene, ligand, and petroleum ether; insoluble in water; MP (-95°C, -139°F); BP (111°C, 232°F); DN (0.8661 g/mL at 20°C); LSG (0.87); ST (29.0 dynes/cm at 20°C); VS (0.590 cP at 20°C); CP (157.3 J/K-mol liquid at 25°C); HV (155 Btu/lb, 86.1 cal/g,  $3.61 \times 10^5$  J/kg); VD (3.14); VP (22 mmHg at 20°C, 36.7 mmHg at 30°C); OT (2.14 ppm, 8 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** non-corrosive liquid; can be oxidized in air to form phenol, but the reaction requires catalysis; may accumulate static electricity; FP (4°C, 40°F); LFL/UFL (1.2%, 7.1%); AT (480°C, 896°F); HC (-17,430 Btu/lb, -9686 cal/g,  $-405.5 \times 10^5$  J/kg); HF (12.4 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; very dangerous fire hazard; flashback along vapor trail may occur; vapor may explode if ignited in a confined area; liquid may float on water to an ignition source and spread fire; reacts explosively with 1,3-dichloro-5,5-dimethyl-2,4-imidazolididione, dinitrogen tetraoxide, concentrated nitric acid, sulfuric acid and nitric acid, silver perchlorate, bromine trifluoride, uranium hexafluoride, and sulfur dichloride; forms an explosive mixture with tetranitromethane; reacts vigorously with strong oxidizers; decomposition emits toxic fumes which can react vigorously with oxidizing materials; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (central nervous system effects, hallucinations, distorted perceptions, motor activity changes, bone marrow changes, irritates eyes and skin); skin absorption (dizziness, headache, anesthesia, respiratory arrest); contact (dryness of skin, dermatitis); ingestion (vomiting, diarrhea, depressed respiration).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 50mg/kg; inhalation-human TCLo 200 ppm; toxic effect: central nervous system, blood effects, brain; inhalation-man TCLo 100 ppm; toxic effect: central nervous system; eye-human 300 ppm.

**ACUTE HEALTH RISKS:** central nervous system excitations; central nervous system depression; mild upper respiratory tract irritation; mild eye irritation; lacrimation; metallic taste; nausea; hilarity; lassitude; drowsiness; impaired balance; paresthesia; vision disturbances; dizziness; headache; narcosis; collapse; death from respiratory failure or ventricular fibrillation.

**CHRONIC HEALTH RISKS:** hepatotoxicity; nephrotoxicity; severe muscle weakness; cardiac arrhythmia; gastrointestinal disturbances; neuropsychiatric complaints; anemia, leukopenia, and enlarged liver may be found in rare cases.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm (skin); OSHA PEL TWA 200 ppm; OSHA PEL CL 300 ppm; OSHA PEL 500 ppm/10m max. peak; NIOSH REL TWA 100 ppm (375mg/m<sup>3</sup>); NIOSH REL STEL 150 ppm (560 mg/m<sup>3</sup>); IDLH 500 ppm.

**PERSONAL PROTECTION:** impervious outerwear should be worn; wear chemical-resistant gloves; rubber is not recommended; wear safety goggles and self-contained breathing apparatus; drench-type showers and eye-wash fountains should be provided.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in fume hood; absorb as much as possible in noncombustible materials such as dry earth or sand; flush remaining toluene with large amounts of water but not

into confined spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a sanitary landfill; cautiously ignite small amounts in open areas; dissolve in flammable solvent and atomize large amounts in a suitable combustion chamber; store in a cool, dry area; outside storage preferred; inside storage should be in a standard flammable liquid storage room or cabinet; keep away from sparks, heat, and open flame; separate from oxidizing materials.

**REGULATORY INFORMATION:** CA2; S1; S32-49; S50-b18; S61-a16; S62'-16; S10; R2-54; R3; R4; R5; R6; R8; R9; U waste # (U220); Reportable Quantity (RQ): 1000 lbs (454 kg); Sf1; Sf3; CW1; CW2; CW3; CW4; CW5; T120-a; A2; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the manufacture of benzoic acid, benzaldehyde, explosives, dyes, and many other organic compounds; used as a solvent for paints, lacquers, gums, and resins; used in cements, solvents, spot removers, cosmetics, antifreezes, and inks; a constituent of asphalt and naphtha; also used in fuel blending.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

## **TOLUENE-2,4-DIISOCYANATE (CH<sub>3</sub>C<sub>6</sub>H<sub>3</sub>(NCO)<sub>2</sub>, 174.17)**

**CAS/DOT IDENTIFICATION #:** 584-84-9/UN2078

**SYNONYMS:** 2,4-diisocyanato-1-methylbenzene, 2,4-diisocyanatotoluene, 4-methylphenylene diisocyanate, 4-methyl-phenylene isocyanate, toluene diisocyanate, 2,4-toluenediisocyanate.

**PHYSICAL PROPERTIES :** colorless to faint yellow liquid; sharp, pungent odor; miscible with alcohol, diglycol monomethyl ether, ether, acetone, carbon tetrachloride, benzene, chlorobenzene, kerosene, and olive oil; insoluble in water; MP (20-22°C, 67-71°F); BP (251°C, 484°F); DN (1.2244 g/mL at 20°C); LSG (1.22); VD (6.0); VP (1 mmHg at 80°C); OT (0.17 ppm).

**CHEMICAL PROPERTIES:** combustible liquid; darkens on exposure to sunlight; hazardous polymerization may occur; reaction with concentrated alkaline compounds such as sodium hydroxide or tert-amines may cause run-away polymerization; reacts slowly with water to form carbon dioxide and polyureas; reacts vigorously with bases, strong oxidizing agents, organic acids, alcohols, and amines; may cause foam and spatter; FP (127°C, 260°F); LFL/UFL (0.9%, 9.5%); AT (>619°C, >1146°F).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 3, Flammability 1, Reactivity 3; hazardous polymerization and/or hazardous decomposition may occur on exposure to water or elevated temperatures; explosive in vapor form when exposed to heat or flame; violent polymerization reaction with bases or acyl chlorides; reacts violently with bases, organic acids, organometallic compounds, alcohols, and amines; self-reacts at elevated temperatures to form dimers, trimers and polymers giving off carbon dioxide and heat; reaction with water releases carbon dioxide; closed containers may rupture violently when heated; storage in polyethylene containers is hazardous due to absorption of water through the plastic; emits highly toxic fumes of oxides of nitrogen and hydrogen cyanide when heated to decomposition; use carbon dioxide or dry chemical powder for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (respiratory obstruction, cough, sputum, pulmonary effects, gastrointestinal changes, irritates eyes, skin and nose); contact (severe dermatitis, bronchial spasm, conjunctivitis, lacrimation, skin sensitization).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLO 20ppb/2Y; toxic effect: pulmonary system; inhalation-human TCLO 500 ppb; toxic effect: nose, pulmonary system; inhalation-human TCLO 80 ppb; toxic effect: nose, pulmonary system, eye; inhalation-woman TCLO 300ppt/8H/5D; toxic effect: pulmonary system.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; choking sensation; coughing; chest pain; retrosternal soreness; nausea; vomiting; abdominal pain; bronchial spasm; pulmonary edema; breathing difficulty; conjunctivitis; lacrimation; skin sensitization; severe allergic respiratory reaction.

**CHRONIC HEALTH RISKS:** bronchopneumonia; weight loss; decreased lung function; asthma; dermatitis; effects on liver, blood, and kidneys; carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.005 ppm (0.036 mg/m<sup>3</sup>); ACGIH TLV STEL 0.02 ppm (0.143mg/m<sup>3</sup>); OSHA PEL TWA 0.005 ppm (0.036 mg/m<sup>3</sup>); OSHA PEL STEL 0.02 ppm (0.143 mg/m<sup>3</sup>); NIOSH REL TWA 0.005 ppm; NIOSH REL CL 0.02 ppm/10M; IDLH 2.5 ppm.

**PERSONAL PROTECTION:** wear special protective clothing and chemical-resistant gloves; wear chemical safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible in noncombustible materials such as dry earth or sand; flush remaining contaminant with large amounts of water but not into spaces such as sewers because of danger of explosions; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** large quantities can be atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; separate from oxidizing materials, acids, alkalies, amines and water.

**REGULATORY INFORMATION:** CA2; Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf2; A1; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used in the manufacture of polyurethane foams and other elastomers; used as a cross-linking agent for nylon 6.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 12; 13; 14; 19.

### **o-TOLUIDINE (CH<sub>3</sub>C<sub>6</sub>H<sub>4</sub>NH<sub>2</sub>, 107.17)**

**CAS/DOT IDENTIFICATION #:** 95-53-4/UN1708

**SYNONYMS:** 1-amino-2-methylbenzene, 2-amino-1-methylbenzene, o-aminotoluene, 2-aminotoluene, 1-methyl-2-aminobenzene, o-methylaniline, 2-methylaniline, ortho-toluidine.

**PHYSICAL PROPERTIES :** colorless to pale-yellow liquid; may darken to a reddish brown on exposure to air and light; aromatic, aniline-like odor; soluble in alcohol, ether, and

dilute acids, slightly soluble in water; MP (-14.7°C, 5.5°F); BP (200°C, 392°F); DN (1.004 g/mL at 20°C); LSG (1.00); ST (43.55 dynes/cm at 20°C); CP (130.2 J/K-mol gas at 25°C); HV (179.1 Btu/lb, 99.5 cal/g, 4.16 x 10<sup>5</sup> J/kg); VD (3.69); VP (<1 mmHg at 20°C); OT (0.25 ppm).

**CHEMICAL PROPERTIES:** combustible liquid; behavior comparable to that of aniline; reacts vigorously with strong oxidizers, nitric acid, and bases; FP (85°C, 185°F); LFL/UFL (1.5%, NA); AT (482°C, 900°F); HC (-16,180 Btu/lb, -8,90 cal/g, -376 x 10<sup>6</sup> J/kg); HF (-6.3 kJ/mol liquid at 25°C, 56.4 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; NFPA rating Health 3, Flammability 2, Reactivity 0; flammable when exposed to heat or flame; hypergolic reaction with red fuming nitric acid; reacts strongly with oxidizing materials; may form explosive mixtures with air; incompatible with strong oxidizers, nitric acid and bases; emits toxic fumes of oxides of nitrogen when heated to decomposition; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (pallor, low-grade secondary anemia, fatigability, and loss of appetite); absorption (nausea, vomiting, coma, blue discoloration of lips, nails, and skin); contact (eye irritation, skin burns).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man TCLo 25mg/m<sup>3</sup>; toxic effect: kidney, blood effects; unscheduled DNA synthesis-human HeLa cell 50µL/L.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; headache; weakness; dizziness; drowsiness; anoxia; microhematuria; urine volume increase; formation of methemoglobinemia; possible cyanosis; destructive to tissues of mucous membranes; difficulty in breathing; psychic disturbances; irritation of kidneys and bladder; skin burns; dermatitis.

**CHRONIC HEALTH RISKS:** chronic methemoglobinemia; low-grade secondary anemia; various degrees of pallor; fatigability; loss of appetite; human mutation data reported; may alter genetic material; confirmed carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 2 ppm (skin); OSHA PEL TWA 5 ppm (22 mg/m<sup>3</sup>)(skin); IDLH 50 ppm.

**PERSONAL PROTECTION:** wear full protective clothing; wear chemical resistant gloves and chemical safety goggles; employ self-contained breathing apparatus; avoid inhalation of vapors, contact of liquid on skin, and ingestion.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb as much as possible with noncombustible materials such as dry earth or sand; high-efficiency particulate arrester or charcoal filters can be used to minimize amount of carcinogen in exhausted air; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and soda ash mixture; burn in incinerator; dissolve in flammable solvent (alcohols, benzene, etc.), and burn in incinerator equipped with afterburner and scrubber; store in cool, dry location; separate from oxidizing materials; store away from heat and sunlight.

**REGULATORY INFORMATION:** CA2; R3; R4; R5; U waste # (U328); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf3; A1; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used in the preparation of ion exchange resins; used in the synthesis of dye stuffs and other intermediates; antioxidant in rubber manufacturing; laboratory reagent in glucose analysis; used in the manufacture of rodine products; used in printing textiles blue-black; used in making various colors fast to acids.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

### TRIBUTYL PHOSPHATE ( $\text{CH}_3[\text{CH}_2]_3\text{O}$ )<sub>3</sub>PO, 223.36)

**CAS/DOT IDENTIFICATION #:** 126-73-8/NA

**SYNONYMS:** butyl phosphate, tbp, tributyl ester of phosphoric acid, tri-n-butyl phosphate.

**PHYSICAL PROPERTIES :** colorless to pale-yellow liquid; odorless; miscible with common organic solvents and diluents; soluble in water; soluble in ether, benzene, and carbon disulfide; soluble in all proportions in alcohol; MP (< -80°C, <112°F); BP (289°C, 552°F decomposes); DN (0.982 g/mL at 20°C); LSG (0.98); VS (38.6 SSU at 85°C); HV (55.1 cal/g at 289°C); VD (9.20); VP (0.004 mmHg at 20°C); 127 mmHg at 177°C).

**CHEMICAL PROPERTIES:** stable; diesters are more acidic and hydrolyze more readily than the triesters; will attack some forms of plastics, rubber, and coatings; FP (146°C, 295°F); LFL/UFL (NA); AT (>482°C, >900°F).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating Health 2, Flammability 1, Reactivity 0; incompatible with alkalis, oxidizers, water and moist air; toxic gases and vapors, such as phosphoric acid fume and carbon monoxide, may be released in a fire; use carbon dioxide, dry chemical, fog or mist for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, skin, and respiratory system); ingestion (headache, nausea).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if ingested, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; respiratory irritation; headache; nausea; stimulation of central nervous system.

**CHRONIC HEALTH RISKS:** no known chronic health risks in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2ppm; OSHA PEL TWA 5mg/m<sup>3</sup>; NIOSH REL TWA 0.2 ppm (2.5 mg/m<sup>3</sup>); IDLH 30ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); use impervious clothing, gloves, and face-shields; use splash-proof safety goggles.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and cautiously evaporate in a fume hood; atomize large quantities in a suitable combustion chamber equipped with effluent gas cleaning device.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible in noncombustible materials such as dry earth, sand, or vermiculite and place in a secured sanitary landfill; atomize in a suitable combustion chamber equipped with effluent gas cleaning device; store in a cool, dry location with adequate ventilation; keep away from oxidizers and alkalis.

**REGULATORY INFORMATION:** T799-4360; A1; CAL.

**OTHER COMMENTS:** has been used as an antifoaming agent; used as a plasticizer for lacquers, vinyl resins, plastics, and cellulose esters; used as a solvent in extraction of metals, including uranium and thorium; useful as a heat-exchange medium in aircraft engines.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 16.

### 1,1,2-TRICHLOROETHANE (CHCl<sub>2</sub>CH<sub>2</sub>Cl, 133.40)

**CAS/DOT IDENTIFICATION #:** 79-00-5/NA

**SYNONYMS:** ethane trichloride, 1,1,2-trichloroethane, beta-trichloroethane, 1,2,2-trichloroethane, vinyl trichloride.

**PHYSICAL PROPERTIES :** colorless, heavy liquid; mobile liquid; sweet, chloroform-like odor; miscible with alcohols, ether, esters, ketones, and many other organic liquids; insoluble in water; not an inert solvent; highest solvent power of the chlorinated hydrocarbons; MP (-36°C, -34°F); BP (113°C, 235°F); DN (1.4416 g/mL at 20°C); LSG (1.44); CP (150.9 J/K-mol liquid at 25°C); HV (40.24 kJ/mol at 25°C); VD (4.55); VP (19 mmHg at 20°C, 40mmHg at 35°C).

**CHEMICAL PROPERTIES:** combustible liquid; forms dense soot; stable under normal temperatures and pressures; hazardous polymerization will not occur; reacts with active metals such as aluminum, magnesium powders, sodium, and potassium; reaction with strong bases and strong oxidizers; FP (NA); LFL/UFL (6%, 15.5%); AT (460°C, 860°F); HC (NA); HF (-191.5 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid; no flash point in conventional closed tester; vapors in containers may explode if exposed to a high energy source; violent reaction with potassium, sodium, magnesium, and aluminum; incompatible with strong oxidizing agents and caustics; combustion by-products may include carbon monoxide, carbon dioxide, phosgene, and hydrogen chloride gas; use water spray, dry chemical powder, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (narcotic effects, irritates eyes, mucous membranes, and upper respiratory tract); skin absorption (stinging and burning sensations, whitening of the skin); ingestion (abdominal cramps, nausea, vomiting, diarrhea); contact (narcotic effects, dermatitis, severe eye irritant).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and respiratory system; dizziness; abdominal cramps; narcosis; central nervous system depression; liver and kidney damage; whitening of skin; destructive to tissues of mucous membranes; dermatitis.

**CHRONIC HEALTH RISKS:** effects on the liver, kidneys, and cardiovascular system; immune system effects; severe eye and skin irritant; mutagen; may alter genetic materials; possible human carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (55mg/m<sup>3</sup>)(skin); OSHA PEL TWA 10 ppm (45 mg/m<sup>3</sup>)(skin); NIOSH REL TWA 10 ppm (45 mg/m<sup>3</sup>)(skin); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear boots, apron and chemical-resistant gloves; wear chemical safety goggles or a face shield; use positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** use appropriate foam to blanket release and suppress vapors; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite; any release in excess of 1 lb. should be reported; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; separate from aluminum, ammonia, and oxidizing materials.

**REGULATORY INFORMATION:** CA2; S1; S32-74; S50-b33; S61-a21; S62-7; S10; R2-56; R3; R4; R5; R7; R8; U waste # (U227); Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf1; Sf3; CW4; CW5; A1; CAL; DOT hazard class/division (NA); labels (NA).

**OTHER COMMENTS:** used as a solvent for fats, oils, waxes, natural resins, alkaloids, and chlorinated rubbers; used as a chemical intermediate in the formation of 1,1-dichloroethene; used in the synthesis of organic compounds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 12; 13; 14; 19.

## TRICHLOROETHYLENE (CICH=CCl<sub>2</sub>, 131.38)

**CAS/DOT IDENTIFICATION #:** 79-01-6/UN1710

**SYNONYMS:** acetylene trichloride, 1,1-dichloro-2-chloroethylene, ethynyl trichloride, ethylene trichloride, tce, trichloroethene, trilene.

**PHYSICAL PROPERTIES :** clear, colorless liquid; mobile liquid; low-boiling; chloroform-like odor, miscible with alcohol, ether, chloroform, acetone, and carbon tetrachloride; soluble in most organic solvents; slightly soluble in water; dissolves most fixed and volatile oils; MP (-85°C, -121°F); BP (87°C, 189°F); DN (1.4649 g/mL at 20°C); LSG (1.46); CP (124.4 J/K-mol liquid at 25°C); HV (34.54 kJ/mol at 25°C); VD (4.53); VP (100 mmHg at 32°C, 58 mmHg at 20°C).

**CHEMICAL PROPERTIES:** non-flammable; photoreactive liquid; slowly decomposes by light in the presence of moisture; industrial grades may contain stabilizers such as triethylamine; medicinal grade may contain thymol as a preservative; reacts with strong caustics, alkalies, and chemically-active metals; FP (none); LFL/UFL (8%, 10.5%); AT (420°C, 788°F); HF (-43.6 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** combustible liquid, but burns with difficulty; NFPA rating Health 2, Flammability 1, Reactivity 0; no flash point in conventional closed tester; solvent residue or vapor in closed equipment can explode if subjected to high energy sources; reacts violently with aluminum, barium, dinitrogen tetraoxide, lithium, magnesium, liquid oxygen, ozone, potassium hydroxide, potassium nitrate, sodium, sodium hydroxide, and titanium;

reacts with water under heat and pressure to form hydrogen chloride gas; reacts with alkali and epoxides to form spontaneously flammable gas dichloroacetylene; heating to decomposition emits toxic fumes of Cl<sup>-</sup>; use water spray or agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (eye effects, somnolence, hallucinations, headache, drowsiness, narcosis, anesthesia, jaundice, dizziness, difficult breathing, irritates eyes, nose and throat); ingestion (gastrointestinal disturbances, nausea, vomiting); contact (irritation or skin burns, irritation of mucous membranes, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human T<sub>CLo</sub> 160ppm/83M; toxic effect: central nervous system; inhalation-human T<sub>CLo</sub> 6900mg/m<sup>3</sup>/10M; toxic effect: central nervous system; inhalation-human T<sub>DLo</sub> 812 mg/kg; toxic effect: central nervous system, gastrointestinal tract, liver; inhalation-man T<sub>CLo</sub> 110ppm/8H; toxic effect: eye, central nervous system; oral-man T<sub>DLo</sub> 2143 mg/kg; toxic effect: gastrointestinal tract; oral-human LD<sub>Lo</sub> 7g/kg.

**ACUTE HEALTH RISKS:** headache; vertigo; visual disturbances; tremors; somnolence; hallucinations; distorted perceptions; nausea; vomiting; jaundice; narcosis; anesthesia; irritation of eyes, skin and respiratory system.

**CHRONIC HEALTH RISKS:** ventricular fibrillation resulting in cardiac failure; liver damage; dermatitis; damage to other organs from chronic exposure; potential occupational carcinogen.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; ACGIH TLV STEL 200 ppm; OSHA PEL TWA 100 ppm; OSHA PEL CL 200 ppm; OSHA PEL 300ppm/5 M max peak/2H; NIOSH REL TWA 250 ppm; NIOSH REL CL (waste anesthetic gases) 2 ppm/1H; IDLH 1000 ppm.

**PERSONAL PROTECTION:** wear neoprene or polyvinyl alcohol suit or aprons for splash protection; neoprene or polyvinyl-alcohol-type gloves and neoprene safety shoes are also recommended; wear chemical safety goggles and self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; absorb as much as possible with non-combustible materials such as dry earth, sand or vermiculite; control runoff and dispose of properly.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth or sand and place in a secured, sanitary landfill; destroy by high-temperature incineration with hydrochloric acid scrubber; store in a cool, dry location; preserve in sealed, light-resistant containers; avoid prolonged exposure to excessive heat; separate from active metals; isolate from open flames and combustibles.

**REGULATORY INFORMATION:** CA2; S1; S32-1; S50-a5; S62'-4; S10; R1; R2-57; R3; R4; R5; R7; R8; R9; D waste # (D040); U waste # (U228); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf3; CW1; CW2; CW3; CW4; CW5; A1; A2; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as an extraction solvent for fats, oils, and waxes; used as a solvent for cellulose esters and ethers; useful in metal degreasing and dry cleaning; diluent in paints and adhesives; refrigerant and heat-exchange liquid; chemical intermediate in the manufacture of organic chemicals and pharmaceuticals, such as chloroacetic acid.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 9; 10; 12; 14.

**TRICHLORONAPHTHALENE (C<sub>10</sub>H<sub>5</sub>Cl<sub>3</sub>, 231.50)****CAS/DOT IDENTIFICATION #:** 1321-65-9/ none**SYNONYMS:** halowax<sup>®</sup>, nibren wax, seekay wax.**PHYSICAL PROPERTIES :** colorless to pale-yellow solid; aromatic odor; insoluble in water; MP (92.78°C, 199°F); BP (304.44-354.44°C, 580-670°F); DN (1.58 g/cm<sup>3</sup> at 20°C); SG (1.58); VD (8.0); VP (< 1 mmHg at 20°C); OT (NA).**CHEMICAL PROPERTIES:** combustible solid; can react vigorously with strong oxidizing agents; heat may contribute to instability; will degrade in the atmosphere by the vapor-phase reaction with photochemically produced hydroxyl radicals with an estimated half-life of about 8 days; FP (200°C, 392°F); LFL/UFL (NA); AT (none to boiling point).**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating (NA); contact with strong oxidizers may cause fires and explosions; toxic gases and vapors, such as carbon monoxide, hydrogen chloride, and phosgene may be released in a fire; use carbon dioxide, foam, or dry chemical for firefighting purposes.**HEALTH SYMPTOMS:** inhalation (nausea, illusion of movement, yellow jaundice); skin absorption (fatigue, liver damage); contact (chloracne, acute eczema, irritates eyes).**FIRST AID:** flush eyes immediately with copious amounts of clear water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if ingested, administer syrup of Ipecac, followed by several glasses of water.**HUMAN TOXICITY DATA:** no toxicity data reported in humans.**ACUTE HEALTH RISKS:** irritates skin and eyes; nausea; vertigo (an illusion of movement); acne-like rash; yellow jaundice; dark urine.**CHRONIC HEALTH RISKS:** damage to the liver; toxic hepatitis; fatigue; anorexia; severe acne-form dermatitis of the face, cheeks, periorbital region, and ears.**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg/m<sup>3</sup>(skin); OSHA PEL TWA 5 mg/m<sup>3</sup>(skin); NIOSH REL TWA 5 mg/m<sup>3</sup>(skin); IDLH (NA).**PERSONAL PROTECTION:** wear appropriate protective clothing to prevent any possibility of skin contact with molten material or solutions; chemical-resistant gloves are recommended; use dust- and splash-proof safety goggles; use any self-contained breathing apparatus operated in positive-pressure mode.**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper or other flammable materials, place in an appropriate container, and cautiously burn in a fume hood; remove all sources of ignition.**DISPOSAL AND STORAGE METHODS:** incineration, after mixing with another combustible fuel, is the preferred method of disposal; an acid scrubber is necessary to remove the halo acids produced; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers.**REGULATORY INFORMATION:** A1; CAL (Note: with reference to section 8(d) of TSCA, EPA promulgated a model Health and Safety Data Reporting Rule. The section 8(d) module rule requires manufacturers, importers, and processors of listed chemical substances and

mixtures to submit to EPA copies and lists of unpublished health and safety studies, Trichloronaphthalene is included on this list. [40 CFR 716.120 (7/1/91)]. Section 8(a) of TSCA requires manufacturers of this chemical substance to report preliminary assessment information concerned with production, use, and exposure to EPA).

**OTHER COMMENTS:** employed in lubricants and as an insulation for electrical wire; may be used as a filler to impart flame resistance and improve electrical resistance to polymers; also used as an additive for cutting oil.

**KEY REFERENCES:** 4; 5; 6; 7; 15; 16; 18.

### 1,2,3-TRICHLOROPROPANE (CH<sub>2</sub>ClCHClCH<sub>2</sub>Cl, 147.43)

**CAS/DOT IDENTIFICATION #:** 96-18-4/none

**SYNONYMS:** allyl trichloride, glycerol trichlorohydrin, glyceryl trichlorohydrin, trichlorohydrin..

**PHYSICAL PROPERTIES :** colorless to straw-colored liquid; odor similar to that of trichloroethylene or chloroform; soluble in alcohol and ether; slightly soluble in chloroform; slightly soluble in water; dissolves oils, fats, waxes, chlorinated rubber, and numerous resins; forms azeotropes with camphene, alpha-pinene, and 2,7-dimethyloctane; MP (-14.7°C, 5.5°F); BP (156.85°C, 314.33°F); DN (1.3889 g/mL at 20°C); LSG (1.39); ST (3.77 x 10<sup>-2</sup> N/m, 37.80 dyne/cm at 20°C); VS (2.505 cP at 20°C); CP (183.6 J/K-mol liquid at 25°C); HV (11.22 kcal/mol at 25°C); VD (5.1); VP (3.69 mmHg at 25°C); HS (11.22 kcal/mol at 298K).

**CHEMICAL PROPERTIES:** combustible liquid; generally stable; heat may contribute to instability; will attack some forms of plastics, rubber, and coatings; can react with chemically-active metals, strong caustics and oxidizers; FP (71-73.3°C, 160-164°F); LFL/UFL (3.2%, 12.6%); AT (304°C, 579°F); HC (-414.77 kcal/mol at 25°C); HF (-230.6 kJ/mol liquid at 25°C); T<sub>c</sub> (652K, 714°F); P<sub>c</sub> (3.87 x 10<sup>6</sup> Pa, 2.90 x 10<sup>4</sup> mmHg); V<sub>c</sub> (0.334 m<sup>3</sup>/kg).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 3, Flammability 2, Reactivity 0; moderately flammable when exposed to heat, flames (sparks), or powerful oxidizers; contact with active metals, strong caustics, or with strong oxidizers may cause fires and explosions; toxic gases and vapors, such as hydrogen chloride, phosgene, and carbon monoxide may be released in a fire; use water (as a blanket), spray, mist, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eye, nose and throat); skin absorption (central nervous system depression); ingestion (injury to the liver and kidney).

**FIRST AID:** wash eyes immediately with large amounts of water; immediately wash the skin with copious amounts of soap and water; provide oxygen or respiratory support; if ingested, administer syrup of Ipecac and get immediate medical attention.

**HUMAN TOXICITY DATA:** dna-damage-human lymphocyte 2mmol/L.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; central nervous system depression, drowsiness.

**CHRONIC HEALTH RISKS:** may cause damage to the liver; may exacerbate symptoms of pre-existing skin disorders and impaired pulmonary function; no chronic or reproductive studies are available for quantitative risk analysis.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 ppm (60 mg/m<sup>3</sup>); OSHA PEL TWA 50 ppm (300 mg/m<sup>3</sup>); NIOSH REL TWA 10 ppm (60 mg/m<sup>3</sup>); IDLH 100 ppm.

**PERSONAL PROTECTION:** wear appropriate personal protective clothing including overalls, rubber gloves, boots, and bands around the legs and arms; wear self-contained breathing apparatus operated in positive pressure mode; splash-proof safety goggles are recommended; eyewash fountains and facilities for quick drenching of the body should be provided within immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; absorb as much as possible with noncombustible materials such as dry earth, sand or vermiculite; absorb small quantities on paper towels and cautiously evaporate in a fume hood; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb with vermiculite, dry sand, or earth, and dispose in a secured sanitary landfill; atomize in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device; store in a cool, well-ventilated place; keep out of direct rays of the sun, and away from flames, sparks, active metals, strong caustics, and strong oxidizers.

**REGULATORY INFORMATION:** S3; S40-e14; R2-59; R3; R4; R5; Sfl; Sf3; A1; CAL.

**OTHER COMMENTS:** used as a solvent and extractant for resins, oils, fats, waxes, and chlorinated rubber; used as a paint and varnish remover, and as a commercial solvent for degreasing metal parts; useful in the synthesis of hexafluoropropylene; has also been used in the synthesis of thiokol polysulfide elastomers if some branching of the polymer structure is required.

**KEY REFERENCES:** 4; 5; 6; 7; 15; 16.

### 1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (CCl<sub>2</sub>FCClF<sub>2</sub>, 187.37)

**CAS/DOT IDENTIFICATION #:** 76-13-1/none

**SYNONYMS:** chlorofluorocarbon-113, cfc-113, fluorocarobon-113, freon<sup>®</sup>113, genetron<sup>®</sup>113, halocarbon 113, refrigerant 113, trichlorotrifluoroethane.

**PHYSICAL PROPERTIES :** colorless to water-white liquid; odor like carbon tetrachloride at high concentrations; a gas above 118°F (48°C); vapor is heavier than air and may accumulate in low ceiling spaces; insoluble in water; soluble in alcohol and ether; MP (-35°C, -31°F); BP (47-48°C, 117-118°F); DN (1.5702 g/mL at 20°C); LSG (1.56 at 25°C); CP (170.1 J/K-mol liquid at 25°C); HV (28.4 kJ/mol at 25°C); VD (6.5); REL DN vapor/air mixture (3.0 at 20°C); VP (284 mmHg at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; attacks alloys containing more than 2% magnesium; will attack some forms of plastics, rubber, and coatings; FP (350°C, 662°F); LFL/UFL (unknown); AT (680°C, 1256°F); HF (-805.8 kJ/mol liquid at 25°C); H<sub>f</sub> (2.47 kJ/mol at 238K).

**EXPLOSION and FIRE CONCERNS:** noncombustible liquid at ordinary temperatures; gas will ignite and burn weakly at 1256°F; NFPA rating Health 2, Flammability 0, Reactivity 0; not considered to be a fire hazard; not considered to be an explosion hazard; reacts violently with calcium, potassium sodium, powdered aluminum, zinc, magnesium and beryllium; contact with magnesium alloys containing more than 2% magnesium may cause decomposition; decomposes if in contact with hot surfaces of flames, forming corrosive and toxic fumes of hydrogen fluoride, hydrogen chloride, carbonyl fluoride, phosgene, chlorides and fluorides; in case of fire in surroundings, use any suitable means for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates upper respiratory tract, coughing chest pain, difficulty breathing, confusion, drowsiness, incoordination, excitability, cardiac arrhythmias, asphyxia, lowering of consciousness); skin contact (redness, pain, defatting of skin, dermatitis); eye contact (irritation, redness, pain); ingestion (irritates gastrointestinal tract).

**FIRST AID:** wash eyes immediately with large amounts of water; if frostbite, wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; if not breathing, provide respiratory support; in case of ingestion, induce vomiting immediately; get prompt medical attention.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation to eyes and upper respiratory tract; coughing; chest pains; difficult breathing; drowsiness; acts as an anesthetic; can produce asphyxiation; air concentrations above 2500 ppm may affect psychological and psychomotor functions, resulting in excitement and incoordination; could cause fatal cardiac arrhythmias at high concentrations; may cause effects on central nervous system, resulting in unconsciousness; may cause irritation to gastrointestinal tract.

**CHRONIC HEALTH RISKS:** prolonged contact may have a defatting action; may produce dermatitis; chronic exposure may cause central nervous system effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm (7670 mg/m<sup>3</sup>); ACGIH TLV STEL 1250 ppm (9590 mg/m<sup>3</sup>); OSHA PEL TWA 1000 ppm (7600 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (7600 mg/m<sup>3</sup>); NIOSH TEL STEL 1250 ppm (9500 mg/m<sup>3</sup>); IDLH 2000 ppm.

**PERSONAL PROTECTION:** wear clean body-covering clothing and protective gloves; use chemical safety goggles; use a system of local exhaust ventilation to control emissions at the source and to prevent dispersion into general work area; if the exposure limit is exceeded, wear positive pressure self-contained breathing apparatus; maintain eyewash fountains and quick-drench facilities in immediate work area.

**SPILL CLEAN-UP:** ventilate area of leak or spill; collect leaking and spilled liquid in sealable containers or absorb remaining liquid with an inert material (e.g., dry earth, sand, vermiculite) and remove to a safe place; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb liquid in sand or inert absorbent, and place in a secured, sanitary landfill; dispose of container and unused contents in accordance with federal, state, and local regulations; store in a cool, dry area; use only with adequate ventilation; keep in tightly closed containers; store below boiling point; isolate from metals, alloys, and other incompatible substances; protect against physical damage.

**REGULATORY INFORMATION:** T120-a; A1.

**OTHER COMMENTS:** used as a refrigerant in commercial/industrial air conditioning and industrial process cooling; used as a solvent in degreasing electrical equipment, in the textile industry, and in special laboratory usage; other uses include dry cleaning solvent, fire extin-

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guishers, blowing agents, and a polymer intermediate; useful in the preparation of chlorotrifluoroethylene.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 14; 16.

### **TRIETHYLAMINE ((C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>N, 101.22)**

**CAS/DOT IDENTIFICATION #:** 121-44-8/UN1296

**SYNONYMS:** (diethylamino)ethane, n,n-diethylethanamine, TEA, TEN.

**PHYSICAL PROPERTIES** colorless liquid; strong, fishy, ammonia-like odor; soluble in alcohol and chloroform; very slightly soluble in benzene; practically insoluble in ether; slightly soluble in water above 18.7°C; miscible with water below 18.7°C; MP (-115°C, -175°F); BP(89°C, 193°F); DN (0.7255 g/mL at 25°C); LSG (0.73); ST (20.7 dynes/cm at 20°C); CP(219.9 J/K-mol at 25°C); HV (140 Btu/lb, 80 cal/g, 3.3 x 10<sup>5</sup>J/kg); VD(3.48); VP (54 mmHg at 20°C, 400mmHg at 31.5°C); OT (0.0900 ppm in air).

**CHEMICAL PROPERTIES:** flammable liquid; corrosive; liquid form will attack some forms of plastics, rubber, and coatings; heat contributes to instability; may react with strong acids, strong oxidizers, chlorine, hypochlorite, halogenated compounds, reactive organic compounds, and some metals; FP (-9°C, 16°F); LFL/UFL (1.2%, 8%); AT(249°C, 480°F); HC (-1036.8 kcal/gmol at 20°C); HF (-127.7 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 3, Flammability 3, Reactivity 0; flashback along vapor trail may occur; vapor may explode if ignited in enclosed area; dangerous fire hazard; reacts exothermically with maleic anhydride above 150°C; incompatible with dinitrogen tetroxide; complex with dinitrogen tetroxide explodes below 0°C when undiluted with solvent; reacts vigorously with strong oxidizers; emits toxic fumes of oxides of nitrogen and carbon monoxide when heated to decomposition; use water spray, dry chemical powder, appropriate foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, choking, difficult breathing, loss of consciousness, irritates eyes, nose and throat); contact (severe skin and eye burns); ingestion (nausea, vomiting, convulsions).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support; wash out mouth with water and induce vomiting if conscious.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 12mg/m<sup>3</sup>/11W; toxic effect: eye.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and respiratory system; conjunctivitis; corneal damage; coughing; nausea; pulmonary edema; destructive to tissues of mucous membranes; "smoky vision"; halo vision; seeing "blue haze"; difficult breathing; loss of consciousness.

**CHRONIC HEALTH RISKS:** visual field changes; mutation data reported; experimental reproductive effects; can cause liver and kidney damage; reversible corneal edema.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10ppm; ACGIH TLV STEL 15 ppm; OSHA PEL TWA 25ppm (100 mg/m<sup>3</sup>); IDLH 200ppm.

**PERSONAL PROTECTION:** wear rubber overclothing including rubber gloves; wear chemical safety goggles or face shield; wear self-contained breathing apparatus.

**SPILL CLEAN-UP:** use water spray to cool and disperse vapors; absorb small quantities on paper towels and evaporate in a fume hood; absorb large quantities in noncombustible materials and atomize in a suitable combustion chamber equipped with afterburner and appropriate effluent gas cleaning device; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** add to layer of sodium bisulfate in large evaporating dish; spray with water, neutralize and route to sewage plant; dissolve in flammable solvent and burn in incinerator with afterburner and scrubber; absorb as much as possible in noncombustible materials such as dry earth or sand and atomize in a suitable combustion chamber; store in a cool, dry location; storage should be in tightly closed containers away from heat, sparks, and open flame; separate from oxidizing materials, strong acids, and sources of halogens.

**REGULATORY INFORMATION:** CA2; R4; U waste # (U404); Reportable Quantity (RQ): 5000 lbs. (2270kg); Sf1; Sf3; CW1; VW2; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in the preparation of quaternary ammonium compounds; ingredient of photographic development accelerator, for drying of printing inks, and in carpet cleaners; used as a corrosion inhibitor and as an accelerator for rubber; used as a catalytic solvent in chemical synthesis; also used in the desalination of seawater; use in non-nutritive sweeteners, ketenes, and salts.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 10; 11; 12; 13; 14; 19.

## TRIFLUOROBROMOMETHANE (CBrF<sub>3</sub>, 148.92)

**CAS/DOT IDENTIFICATION #:** 75-63-8/UN1009

**SYNONYMS:** bromotrifluoromethane, fluorocarbon 1301, freon<sup>®</sup>13B1, halocarbon 13B1, halon<sup>®</sup>1301, monobromotrifluoromethane, refrigerant 13B1, trifluoromonobromomethane.

**PHYSICAL PROPERTIES:** colorless, compressed liquefied gas; odorless or slight ethereal odor; insoluble in water; very soluble in chloroform; MP (-168°C, -270°F); BP (-58°C, -72°F); DN (1.54 g/mL liquid at 25°C); LSG (1.5); CP (69.3 J/K-mol gas at 25°C); VD (5.14); VP (> 1 atm at 20°C).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization has not been reported; reacts with chemically-active metals, such as calcium, magnesium, powdered aluminum, and zinc; liquid will attack some forms of plastics, rubber, and coatings; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-648.3 kJ/mol gas at 25°C).

**EXPLOSION and FIRE CONCERNS:** nonflammable gas; not combustible; NFPA rating (NA); vapor is heavier than air and may accumulate in low ceiling spaces causing oxygen deficiency; heating will cause rise in pressure with risk of bursting; attacks plastic, rubber, and coatings; this substance decomposes on contact with hot surfaces or flames, forming toxic fumes of hydrogen bromide and hydrogen fluoride; in case of fire in the surroundings, all extinguishing agents are allowed for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (headache, dizziness, irregular heart beat, unconsciousness); contact (irritates eyes, liquid may cause frostbite).

**FIRST AID:** rinse eyes immediately with large amounts of water for several minutes; on frostbite, rinse affected areas of skin with large amounts of water; if breathing is difficult, provide oxygen; administer artificial respiration if breathing has stopped.

**HUMAN TOXICITY DATA:** no LD<sub>50</sub>/LC<sub>50</sub> information found related to normal routes of occupational exposure.

**ACUTE HEALTH RISKS:** headache; lightheadedness; cardiac arrhythmias; loss of consciousness; liquid may cause frostbite; may cause effects on the central nervous system; may cause irritation of eyes.

**CHRONIC HEALTH RISKS:** no known effects in humans due to long-term exposure.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1000 ppm (6090 mg/m<sup>3</sup>); OSHA PEL TWA 1000 ppm (6100 mg/m<sup>3</sup>); NIOSH REL TWA 1000 ppm (6100 mg/m<sup>3</sup>); IDLH 40,000 ppm.

**PERSONAL PROTECTION:** wear chemical protection suit, including cold-insulating gloves; wear chemical safety goggles in combination with breathing protection; a system of local exhaust ventilation is recommended to control emissions at the source and to prevent dispersion into general work area; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, wear self-contained breathing apparatus; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and disperse vapors; never direct water jet on liquid; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** turn leaking cylinder with leak up to prevent escape of gas in liquid state; store in a cool, dry location; use only with adequate ventilation; fireproof if in building; separate from chemically-active metals.

**REGULATORY INFORMATION:** Sf3; CAL; DOT hazard class/division (2.2); label (non-flammable liquid).

**OTHER COMMENTS:** used as commercial and military fire extinguishant; used in organic synthesis in production of alkene resins; utilized as a refrigerant for food processing and storage; applications as a blowing agent to improve flame retardancy of polyurethane foams.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 14; 16.

## 2,4,6-TRINITROTOLUENE (CH<sub>3</sub>C<sub>6</sub>H<sub>2</sub>(NO<sub>2</sub>)<sub>3</sub>, 227.15)

**CAS/DOT IDENTIFICATION #:** 118-96-7/UN1356

**SYNONYMS:** 1-methyl-2,4,6-trinitrobenzene, 2-methyl-1,3,5-trinitrobenzene, tnt, trinitrotoluene, sym-trinitrotoluene, trinitrotoluol.

**PHYSICAL PROPERTIES :** colorless to pale yellow solid or crushed flakes; odorless; very sparingly soluble in water; soluble in acetone and benzene; less soluble than 2,4,6-trinitrophenol in carbon disulfide, alcohol, and ether; MP (80.1°C, 176.2°F); BP (240°C, 464°F); DN (1.654 g/cm<sup>3</sup> at 20°C); SG (1.65); VD (NA); VP (0.0002 mmHg at 20°C, 0.053 mmHg at 85°C).

**CHEMICAL PROPERTIES:** combustible solid; can be distilled under reduced pressure; can react vigorously with reducing materials; sensitive to light; slow decomposition occurs above 180°C (356°F); FP (NA); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** flammable or explosive when exposed to heat or flame; NFPA rating Health 2, Flammability 4, Reactivity 4; rapid heating will result in detonation; detonates at around 240°C (464°F) but can be distilled safely under reduced pressure; exposure to light may increase impact sensitivity; highly dangerous; one of the most powerful high explosives; contains an oxygen deficiency, therefore, its explosive power can be enhanced by the addition of products that are oxygen-rich; explodes with shock or heating to 297°C (567°F); red lead, sodium carbonate, and potassium hydroxide can reduce the explosive temperature to 192°C, 218°C, and 192°C respectively; may ignite spontaneously when mixed with sodium dichromate and sulfuric acid; reacts with nitric acid and metals (e.g. iron or lead) to form explosive products which are very highly sensitive to shock, friction, or contact with sulfuric and nitric acids; forms explosive aci-nitro salts on reaction with potassium hydroxide dissolved in methanol; deflagration (i.e. very rapid autocombustion) may be induced in molten TNT by sodium hydroxide, potassium iodide, and tetramethyl ammonium octahydrotriborate; contact with strong oxidizers may cause fire; contact with ammonia or with strong alkalis may increase sensitivity to shock; can react vigorously with reducing materials; heating to decomposition emits highly toxic fumes of carbon monoxide and oxides of nitrogen; do not attempt to extinguish large fires; water may be used for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (sneezing, cough, sore throat, irritates mucous membranes); skin absorption (headache, weakness, drowsiness, anemia, liver damage); ingestion (cyanosis, gastrointestinal changes, hallucinations or distorted perceptions); contact (erythema, papules, eczema, cataracts, stains skin, hair and nails yellow).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if ingested, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** oral-human LDLo 28g/kg; toxic effect: central nervous system, pulmonary, gastrointestinal tract.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; destructive to tissues of mucous membranes; sneezing; coughing; sore throat; skin rash; yellow stain of skin, hair and nails; bluish discoloration of the skin; weakness; drowsiness; shortness of breath; yellow jaundice; headache; loss of consciousness.

**CHRONIC HEALTH RISKS:** aplastic anemia; leukocytosis; kidney damage; liver damage; toxic hepatitis; peripheral neuropathy; cardiac irregularities; cataracts of the eyes; menstrual irregularities; sensitization dermatitis; muscular pains.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg/m<sup>3</sup>(skin); OSHA PEL TWA 1.5mg/m<sup>3</sup>(skin); NIOSH REL TWA 0.5 mg/m<sup>3</sup>(skin); IDLH 500 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear impervious clothing, rubber gloves, and dust- or splash-proof safety goggles.

**SPILL CLEAN-UP:** ventilate area of spill; pour or sift onto sodium bicarbonate or a sand-soda ash mixture; physical treatments, such as sorption by activated carbon, ion exchange resins, coagulation, and filtration, may be effective in removing TNT from wastewater; remove all sources of ignition.

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**DISPOSAL AND STORAGE METHODS:** pour or sift onto sodium bicarbonate or a sand-soda ash mixture, mix and package in heavy paper cartons, and burn in incinerator equipped with afterburner and scrubber; mix with a flammable solvent (alcohol, benzene, etc.), and burn in incinerator with afterburners and scrubber; store in a cool, dry location with adequate ventilation; isolate from all sources of fire, electricity or mechanical shock.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (4.1); labels (flammable solid).

**OTHER COMMENTS:** used in the manufacture of shells, bombs, grenades, and mines; use in commercial explosives; used in the production of intermediates for synthesis of dyestuffs and photographic chemicals; one of the most stable of all high explosives; must be detonated by a high velocity initiator such as tetryl or nitramine; may be regarded as the equivalent of 40% dynamite and can be used underwater; relatively expensive explosive and does not compete seriously with dynamite for commercial uses.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 16.

### TRIOORTHOCRESYL PHOSPHATE ((CH<sub>3</sub>C<sub>6</sub>H<sub>4</sub>O)<sub>3</sub>PO, 368.39)

**CAS/DOT IDENTIFICATION #:** 78-30-8/UN2574

**SYNONYMS:** o-cresyl phosphate, tocp, o-tolyl phosphate, tricresyl phosphate, tri-o-cresyl ester of phosphoric acid, tri-o-cresyl phosphate, tri-o-tolyl phosphate.

**PHYSICAL PROPERTIES :** colorless or pale-yellow liquid; solid below 52°F; odorless; slightly soluble in alcohol; soluble in ether; sparingly soluble in water; MP (-25 to -30°C, -13 to -22°F); BP (410°C, 770°F); DN (1.1955 g/mL); LSG (1.20); VD (12.7); VP (0.00002 mmHg at 25°C, 0.02 mmHg at 150°C).

**CHEMICAL PROPERTIES:** combustible liquid; liquid will attack some forms of plastics, rubber, and coatings; can react with oxidizing materials; FP (225°C, 437°F); LFL/UFL (NA); AT (385°C, 725°F).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating Health 2, Flammability 1, Reactivity 0; incompatible with strong oxidizers; toxic gases and vapors, such as phosphoric acid fume and carbon monoxide, may be released in a fire; use carbon dioxide, foam, or dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, vomiting, diarrhea, polyneuritis, degeneration of peripheral motor nerves, paralysis of extremities).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** gastrointestinal disturbances; nausea; vomiting; diarrhea; abdominal pain; peripheral neuropathy.

**CHRONIC HEALTH RISKS:** cramp-like pains in calf muscles; numbness and tingling in feet or hands; weakness of legs and feet; bilateral footdrop; wrist drop; paralysis; death in high concentrations.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1mg/m<sup>3</sup>(skin); OSHA PEL TWA 0.1mg/m<sup>3</sup>; NIOSH REL TWA 0.1 mg/m<sup>3</sup>(skin); IDLH 40 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); use impervious clothing and chemical-resistant gloves; use dust- and splash-proof safety goggles.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand, or vermiculite and place in a secured, sanitary landfill ;atomize in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a flame retarder and plasticizer in chlorinated rubber, nitrile rubber and resins; used in coatings and adhesives based on plasticized cellulose esters; used as a gasoline additive to control pre-ignition; useful as a solvent in the extraction of phenol from gas-plant effluents and coke-oven wastewaters; use as a synthetic lubricant, a waterproofing agent, a primary component of adhesives, and as an intermediate in the synthesis of pharmaceuticals.

**KEY REFERENCES:** 3; 4; 5; 6; 16.

### TRIPHENYL PHOSPHATE ((C<sub>6</sub>H<sub>5</sub>O)<sub>3</sub>PO, 326.30)

**CAS/DOT IDENTIFICATION #:** 115-86-6/NA

**SYNONYMS:** celluflex tpp, phenylphosphate, tpp, triphenyl ester or phosphoric acid.

**PHYSICAL PROPERTIES :** colorless, crystalline solid; faint, phenol-like odor; soluble in alcohol, benzene, ether, chloroform, and acetone; soluble in most lacquers, solvents, thinners, and oils; insoluble in water; MP (49-50°C, 120-122°F); BP (245°C, 473°F at 11 mmHg); DN (1.268 g/cm<sup>3</sup> at 60°C); SG (1.27); VD (NA); VP (1 mmHg at 380°F).

**CHEMICAL PROPERTIES:** combustible solid; stable and fireproof; will attack some forms of plastics, rubber and coatings; no incompatibilities reported; FP (220°C, 428°F); LFL/UFL (NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating Health 2, Flammability 1, Reactivity 0; toxic gases and vapors, such as phosphoric acid fume, carbon monoxide and oxides of phosphorus, may be released in a fire; use carbon dioxide, dry chemical or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (minor changes in blood enzymes, possible neuromuscular disorders and minor gastrointestinal symptoms).

**FIRST AID:** provide oxygen or respiratory support; if swallowed, drink large quantities of water immediately and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** minor changes in blood enzymes; muscle weakness and paralysis have been reported in animals, but not in man; effects on the eye have not been reported.

**CHRONIC HEALTH RISKS:** no chronic health risks reported in humans.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 3mg/m<sup>3</sup>; OSHA PEL TWA 3mg/m<sup>3</sup>; NIOSH REL TWA 3 mg/m<sup>3</sup>; IDLH 1000 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear chemical protective clothing such as aprons, boots, gloves, etc.; use dust- and splash-proof safety goggles.

**SPILL CLEAN-UP:** ventilate area of spill; sweep small quantities onto paper, place in an appropriate container, and cautiously burn in a fume hood; dissolve large quantities in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber.

**DISPOSAL AND STORAGE METHODS:** prepare packages of triphenyl phosphate in paper or other flammable materials and burn in a suitable combustion chamber equipped with effluent gas cleaning device; dissolve in a flammable solvent, such as alcohol, and atomize in a suitable combustion chamber equipped with an effluent gas cleaning device; store in a cool, dry location with adequate ventilation.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** used as a flame-retardant and plasticizer in compounding chlorinated rubber; used in hot extrusion, molding, or other bulk forming plasticized cellulose acetates; useful as a fireproofing agent in manufacture of roofing paper.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 16.

### **TURPENTINE (C<sub>10</sub>H<sub>16</sub>(approx), 136(approx))**

**CAS/DOT IDENTIFICATION #:** 8006-64-2/UN1299

**SYNONYMS:** gumspirits, gum turpentine, spirits of turpentine, steam distilled turpentine, sulfate wood turpentine, turps, wood turpentine.

**PHYSICAL PROPERTIES :** colorless liquid; penetrating, paint odor; immiscible with water; lighter than water; MP (-50 to -60°C, -58 to -76°F); BP (154-170°C, 309-338°F); DN (0.854-0.868 g/mL at 25°C); LSG (0.864 at 20°C); VD (4.84); VP (5 mmHg at 25°C); OT (200 ppm in air).

**CHEMICAL PROPERTIES:** flammable liquid; heat may contribute to instability; can react vigorously with oxidizing materials, especially chlorine; will attack some forms of plastics, rubber, and coatings; acidity none; FP (32-46°C, 90-115°F); LFL/UFL (0.8%, NA); AT (253°C, 488°F).

**EXPLOSION and FIRE CONCERNS:** flammable; NFPA rating Health 1, Flammability 3, Reactivity 0; very dangerous fire hazard; spontaneous heating is possible; moderately explosive in vapor form when exposed to flame; contact with strong oxidizing agents may cause fires and explosions; incompatible with chromium trioxide, tin tetrachloride, hexachloromelamine, trichloromelamine, chlorine, chromyl chloride, and strong oxidizers; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (conjunctiva irritation, hallucinations, antipsychotic changes, headache, pulmonary, and kidney changes); ingestion (nausea, vomiting, diarrhea, abdominal pain); contact (defatting of skin, skin irritation and sensitization).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if ingested, do not induce vomiting; requires immediate medical attention.

**HUMAN TOXICITY DATA:** eye-human 175 ppm; inhalation-human T<sub>CLo</sub> 175 ppm; toxic effect: nose, eye, pulmonary effects; inhalation-human T<sub>CLo</sub> 6g/m<sup>3</sup>/3H; toxic effect: ear, central nervous system; oral-woman T<sub>DLo</sub> 560 mg/kg; toxic effect: kidney; oral-infant T<sub>DLo</sub> 874mg/kg; toxic effect: central nervous system; oral-infant LD<sub>Lo</sub> 1748 mg/kg; unreported-man LD<sub>Lo</sub> 441 mg/kg.

**ACUTE HEALTH RISKS:** irritation of eyes, nose and throat; irritation of lungs; coughing; headache; vertigo; painful urination; dark red urine; albuminuria; hematuria; conjunctivitis; corneal burns; nausea; vomiting; diarrhea; abdominal pain; chemical pneumonia; hallucinations; distorted perceptions; convulsions; unconsciousness; death.

**CHRONIC HEALTH RISKS:** there is little evidence that turpentine vapor at lower concentrations is a chronic systemic poison; defatting agent, causing dermatitis; skin hypersensitivity.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100ppm; OSHA PEL TWA 100 ppm (560mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (560 mg/m<sup>3</sup>); IDLH 800ppm.

**PERSONAL PROTECTION:** use impervious clothing, gloves, and face-shields; use splash-proof safety goggles; use self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; absorb as much as possible with materials such as dry earth or sand; flush remaining turpentine with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand, or vermiculite and place in a secured sanitary landfill; atomize large amounts in a suitable combustion chamber; keep cool and ventilated; avoid impregnation of combustibles with turpentine.

**REGULATORY INFORMATION:** A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used as a thinner for paints, varnishes, and lacquers; used in the preparation of polishes; also used in the manufacture of synthetic camphor and menthol; useful as a rubber solvent and reclaiming agent, and in flavors and perfumes.

**KEY REFERENCES:** 4; 5; 6; 7; 16.

**URANIUM, SOLUBLE and INSOLUBLE COMPOUNDS** (as Uranium) (Soluble and insoluble uranium compounds have variable molecular formulas and variable formula weights. The molecular formula for uranium is U. The formula weight for uranium is 238.00).

**CAS/DOT IDENTIFICATION #:** Soluble and insoluble uranium compounds have variable CAS #s. The CAS # for uranium is 7440-61-1. The DOT identification number for uranium is UN2979.

**SYNONYMS:** Synonyms vary depending upon the specific soluble or insoluble uranium compound. The synonyms for uranium are as follows: uranium-I, uranium metal.

**PHYSICAL PROPERTIES:** Appearance and odor vary depending upon the specific soluble or insoluble uranium compound. Physical properties of uranium metal and several specific soluble and insoluble uranium compounds are provided for illustrative purposes; (uranium) a heavy, silvery-white metal; malleable, ductile, lustrous, metallic element; softer-than-steel; a black powder when obtained by reduction; alpha and beta forms are brittle; the gamma form is softer and more malleable; insoluble in hot or cold water, alkalis, and alcohol; soluble in acids; MP(1133°C, 2071°F); BP(3818°C, 6904°F); DN(19.05 g/cm<sup>3</sup> at 20°C); SG (18.95 at 20°C); ST(1500 or 1575 mN/m liquid); CP(27.7 J/K-mol crystal at 25°C); HV(446.7 kJ/mol); HS(487.9 kJ/mol); VD(not applicable); VP(approximately 0 mmHg at 20°C); Soluble Uranium Compounds (uranium hexafluoride) colorless or white crystalline solid; soluble in liquid bromine, chlorine, chloroform, carbon tetrachloride, and sym-tetrachloroethane; MP(65°C, 149°F); BP(56°C, 133°F at 760 mmHg) (sublimes); DN(3.595 g/mL liquid at 70°C); SG (5.06 at 25°C); CP(166.8 J/K-mol crystal at 25°C); VD(approximately 12); VP(109 mmHg at 20°C); (uranyl nitrate) yellow, rhombic crystals; greenish luster by reflected light; odorless; soluble in water, alcohol, and ether; MP(60.2°C, 140°F) (loses water); BP(118°C, 244°F at 760 mmHg); DN(2.807 g/cm<sup>3</sup>); SG (2.8); VD(not applicable); VP(none, except water of crystallization at 20°C); Insoluble Uranium Compounds (uranium tetrafluoride) green, crystalline powder; odorless; insoluble in water; soluble in concentrated acids and alkalis; MP(>1100°C, >2012°F); BP(1417°C, 2582.6°F) (sublimes); DN(6.70 g/cm<sup>3</sup>); SG (6.7); VD(not applicable); VP(approximately 0 mmHg at 20°C); (uranium hydride) brown-gray to black powder; insoluble in water; MP(decomposes); BP(decomposes at 760 mmHg); DN(10.92 g/cm<sup>3</sup>); SG (10.92); VD(not applicable); VP(approximately 0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** Properties vary depending upon the specific soluble or insoluble uranium compound. Chemical properties of uranium metal and several specific soluble and insoluble uranium compounds are provided for illustrative purposes; (uranium) radioactive metal; strongly electropositive; poor conductor of electricity; tarnishes rapidly in air, forming a layer of dark-colored oxide; orthorhombic alpha-form transforms to tetragonal beta-form at 667.8°C; tetragonal beta-form transforms to body-centered cubic gamma-form at 774.8°C; inert to alkalis; forms solid solutions (for nuclear reactors) with titanium, zirconium, molybdenum, and niobium; reacts very slowly with non-oxidizing acids, such as sulfuric, hydrofluoric, and phosphoric; rapidly soluble in aqueous hydrochloric acid; massive amounts of uranium dissolve at a moderate rate in nitric acid; reacts with nearly all nonmetals; FP (NA); LFL/UFL (NA); AT (20°C, 68°F(cloud); 100°C, 212°F (layer)); H<sub>f</sub>(19.7 kJ/mol); (Soluble and insoluble Uranium Compounds) uranium hexafluoride reacts vigorously with water, forming mainly uranyl fluoride and hydrogen fluoride; dissolution of uranium hexafluoride in nitrobenzene gives a dark red solution fuming in air; uranyl nitrate is a strong oxidizer; uranium tetrafluoride changes to triuranium octaoxide (U<sub>3</sub>O<sub>8</sub>) when heated in air; uranium hydride reacts vigorously with strong oxidizers and is a good conductor of electricity.

**EXPLOSION and FIRE CONCERNS:** uranium metal is a combustible solid, especially turnings and powder; finely divided uranium metal and some uranium compounds may undergo spontaneous ignition in air or oxygen; explosive violence will result when finely divided uranium dissolves in nitric acid; during storage, the metal may form a pyrophoric surface due to the presence of moisture and air; solutions of uranyl nitrate in ether may cause explosion upon exposure to sunlight; uranium turnings and fines stored outdoors in closed containers under water or water-soluble oil will partially convert to the hydride and eventually ignite during hot weather;

contact of uranium hydride with water will form flammable and explosive hydrogen gas; contact of uranium hydride with halogenated hydrocarbons can be violent; hazardous decomposition products, such as hydrogen fluoride and carbon monoxide, may be released when uranium or insoluble compounds decompose; uranium hexafluoride reacts with water to form hydrofluoric acid, a highly corrosive substance; uranium hexafluoride will attack some forms of rubber, plastics, and coatings; hazardous decomposition products such as oxides of nitrogen and hydrofluoric acid, may be released in a fire involving soluble uranium compounds; use graphite, soda ash, powdered sodium chloride, or suitable dry powder for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (soluble uranium compounds may cause lacrimation, conjunctivitis, shortness of breath, cough; insoluble uranium compounds may cause lung damage, as based on animal testing); contact (insoluble uranium compounds may cause dermatitis and radiation damage to the skin; soluble uranium compounds may cause skin burns); ingestion (insoluble uranium compound may cause kidney damage, blood changes, and damage to lymph nodes; soluble uranium compounds may cause red blood cell casts in urine and high blood urea nitrogen).

**FIRST AID:** wash eyes immediately with large amounts of water for several minutes; wash affected areas of skin with plenty of soap and water; if breathing is difficult, provide oxygen; begin artificial respiration if breathing has stopped; if case of ingestion, give large quantities of water immediately and induce vomiting; seek immediate medical attention.

**HUMAN TOXICITY DATA:** no information available in the literature.

**ACUTE HEALTH RISKS:** acute arterial lesions may occur after acute exposures to uranium and its salts; soluble uranium compounds may cause conjunctivitis, lacrimation, coughing, shortness of breath, nausea, vomiting, skin burns, red blood cell casts of urine, high blood urea nitrogen, and albuminuria.

**CHRONIC HEALTH RISKS:** direct contact with uranium metal or insoluble uranium compounds may cause dermatitis; prolonged exposure to insoluble uranium compounds may cause an increase in cancer of the lymphatic and blood-forming tissues in man; prolonged contact with the skin may cause radiation damage to the skin; may cause irreversible kidney damage; the function of the bone marrow is at risk; uranium or insoluble compounds has been reported to cause lung damage in animals; uranium and uranium compounds are potential occupational carcinogens as a result of their ability to emit alpha-particles and radioactive decay products (e.g., radon).

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.2 mg(U)/m<sup>3</sup>; ACGIH TLV STEL 0.6 mg(u)/m<sup>3</sup>; OSHA PEL TWA 0.05 mg(soluble compounds as U)/m<sup>3</sup>, 0.25 mg (insoluble compounds as U)/m<sup>3</sup>; NIOSH REL TWA 0.05mg (soluble compounds as U)/m<sup>3</sup>, 0.2 mg (insoluble compounds as U)/m<sup>3</sup>; NIOSH REL STEL 0.6 mg (insoluble compounds as U)/m<sup>3</sup>, 10 mg (insoluble compounds as U)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear appropriate chemical protective clothing, water contaminated with alpha and gamma radiation should not be allowed to contact skin or personal clothing; wear waterproof protection; a mask with air filter may be required if the radioactivity is airborne; enclose operations and/or use local exhaust ventilation at site of chemical release; use dust-and splash-proof safety goggles; appropriate respirators are needed in areas where exposure would be above the permissible exposure level; wear self-contained breathing apparatus in unknown concentrations or IDLH conditions; maintain eyewash baths and safety showers in work area.

**SPILL CLEAN-UP:** ventilate area of spill; cautiously collect spilled material and deposit in sealed containers; liquid containing soluble or insoluble uranium compounds should be ab-

sorbed in dry earth, sand or vermiculite; uranium chips or turnings which are spilled should be covered with oil in order to prevent fire.

**DISPOSAL AND STORAGE METHODS:** disposal of wastes should be in accordance with guidelines set forth by the nuclear regulatory commission; burial at an authorized radioactive burial site is recommended; store in a cool, dry location; maintain adequate ventilation; store in concrete tanks lined with steel; containers of compressed alumina have been recommended, as this material remains impervious to water; uranium hexafluoride is best handled in copper apparatus; storage in salt formations is under serious consideration because they are self-sealing and free from water.

**REGULATORY INFORMATION:** A1; DOT hazard class/division (7) labels (radioactive, spontaneously combustible).

**OTHER COMMENTS:** soluble uranium compounds are used in the manufacture of dye-stuff intermediates and preparation of oxides; utilized in the manufacture of ceramic glazes; uses as photographic intensifiers and in x-ray technology; miscellaneous uses include textile printing, anti-fungal agents, electroplating additives, and bacterial oxidants; insoluble uranium compounds are used as chemical intermediates in the preparation of uranium compounds; use for nuclear technology, for example, in nuclear reactors as fuel and to pack nuclear fuel rods; employed in the ceramics industry for pigments, coloring porcelain, painting on porcelain, and enameling; also used as catalysts for many reactions and in the production of fluorescent glass.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 10; 16.

### **VANADIUM RESPIRABLE DUST AND FUME (V<sub>2</sub>O<sub>5</sub>, 181.88)**

**CAS/DOT IDENTIFICATION #:** 1314-62-1/UN2862

**SYNONYMS:** divanadium pentoxide, vanadic anhydride, vanadium oxide, vanadium pentoxide, vanadium pentoxide.

**PHYSICAL PROPERTIES :** yellow-orange powder or dark gray flakes dispersed in air; finely divided particulate dispersed in air; odorless; soluble in concentrated acids and alkalis; soluble in acetone; slightly soluble in water insoluble in alcohol; MP (690°C, 1274°F); BP (1750°C, 3182°F decomposes); DN (3.357 g/cm<sup>3</sup> at 18°C); SG (3.36); CP (127.7 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** noncombustible solid; mild oxidizing agent; amphoteric (having the capacity of behaving either as an acid or a base); its acid solutions are reduced by sulfur dioxide, zinc hydrochloric acid, and by evaporation with hydrochloric acid; forms yellow and red solutions in concentrated acids; forms vanadates in alkalis; FP (NA); LFL/UFL (NA); AT (NA); HF (-1550.6 kJ/mol crystal at 25°C); H<sub>f</sub> (64.5 kJ/mol at 943K).

**EXPLOSION and FIRE CONCERNS:** not flammable, but may increase intensity of fire when in contact with combustible materials; NFPA rating (not available); mixtures with calcium + sulfur + water may ignite spontaneously; incompatible with lithium, chlorine trifluoride, and peroxyformic acid; heating to decomposition emits irritating fumes of oxides of nitrogen; use flooding quantities of water for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (asthma, cough, wheezing, dyspnea, conjunctiva irritation, pain in chest, bronchitis, bronchospasm, upper respiratory irritation); ingestion (irritation of mouth and stomach, green-black discoloration of the tongue, metallic taste, gastrointestinal disturbances); contact (papular skin rash, eczema).

**FIRST AID:** wash eyes immediately with large amounts of water; flush skin immediately with large amounts of soap and water; provide oxygen or respiratory support; if swallowed, have victim drink water or milk, and induce vomiting.

**HUMAN TOXICITY DATA:** inhalation-human TCLO 346 mg/m<sup>3</sup>; toxic effect: pulmonary; inhalation-human TCLO 1 mg/m<sup>3</sup>/8H; toxic effect: pulmonary, eye.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and throat; irritation of respiratory tract; skin pallor; greenish-black tongue; chest pain; difficulty in breathing ; palpitations; metallic taste; wheezing; bronchitis; lung changes; sputum irritation; irritation of conjunctiva; gastrointestinal disturbances; fine rales; bronchospasm; tremors in the fingers and arms.

**CHRONIC HEALTH RISKS:** responses to prolonged exposure are acute, never chronic; however, chronic responses may include bronchiolar constriction, such as asthma; eczema may also develop.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 mg (V<sub>2</sub>O<sub>5</sub>)/m<sup>3</sup>; OSHA PEL CL (resp. dust) 0.5 mg (V<sub>2</sub>O<sub>5</sub>)/m<sup>3</sup>; OSHA PEL CL (fume) 0.1 mg (V<sub>2</sub>O<sub>5</sub>)/m<sup>3</sup>; NIOSH REL CL (vanadium compounds) 0.05 mg (V)/m<sup>3</sup>/15M; IDLH 35 mg(V)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear acid restraining clothing; wear acid resistant gloves and soft goggles; an acid vapor mask and face shield is also recommended.

**SPILL CLEAN-UP:** ventilate area of spill; shovel dust into suitable dry container, and place in a secured sanitary landfill.

**DISPOSAL AND STORAGE METHODS:** may be disposed in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; keep away from incompatibles.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): 1000 lbs (454 kg); A1; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used as a catalyst in the oxidation of sulfur dioxide to sulfur trioxide and alcohol to acetaldehyde; used in the manufacture of yellow glass; also used as an inhibitor to ultraviolet light transmission in glass and as a depolarizer; useful as a developer in photography.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 8; 11; 12; 14.

### **VEGETABLE OIL MIST (not available, varies)**

**CAS/DOT IDENTIFICATION #:** 68956-68-3/NA

**SYNONYMS:** vegetable mist, vegetable oil, viscoleo oil.

**PHYSICAL PROPERTIES :** an oil extracted from the seeds, fruit, or nuts of vegetables or other plant matter; considered to be a mixture of mixed glycerides, including cottonseed, linseed, corn, coconut, olive, peanut, tung, perilla, oiticica, and babassu; insoluble in water; MP (unknown); BP (unknown); SG (0.91 - 0.95 at 68°F); VP (unknown).

**CHEMICAL PROPERTIES:** combustible liquid antioxidants may be added to prevent breakdown during storage and to insure maximum stability; no incompatibilities and reactivities reported; FP (161.7-282°C, 323-540°F); LFL/UFL (unknown); AT (unknown); HC (unknown); HF (unknown).

**EXPLOSION and FIRE CONCERNS:** combustible; nuisance mist; quite difficult to stabilize with normal quantities of antioxidants due to high degree of unsaturation; heating to decomposition emits acrid smoke and irritating fumes.

**HEALTH SYMPTOMS:** inhalation (discharge of tears, irritates eyes, skin and respiratory system).

**FIRST AID:** wash eyes immediately with large amounts of water, occasionally lifting lower and upper lids; provide respiratory support or oxygen; other measures are usually not necessary.

**HUMAN TOXICITY DATA:** controlled trial of the effect of linolenic acid has shown incidence of coronary heart disease; vegetable oil aerosol spray intoxication has been reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, and respiratory system; lacrimation (discharge of tears).

**CHRONIC HEALTH RISKS:** no chronic health risks reported in humans.

**EXPOSURE GUIDELINES:** OSHA PEL TWA 15 mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 5 mg (respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>; NIOSH REL TWA 5 mg (respirable fraction)/m<sup>3</sup>; ACGIH TLV TWA 10 mg (other than irritant oils)/m<sup>3</sup>.

**PERSONAL PROTECTION:** no recommendation is made specifying the need for personal protective equipment of the body; no recommendation is made of specifying the need for eye protection.

**SPILL CLEAN-UP:** effluent water from vegetable oil refining was treated by the addition of calcium chloride followed by a clarification step; wastewater containing emulsion or dispersion may be treated by passing it through a magnesium clinker column.

**DISPOSAL AND STORAGE METHODS:** dispose of in accordance with federal, state, and local regulations; store in a cool, dry, well-ventilated area; separate from any area where the fire hazard may be acute.

**REGULATORY INFORMATION:** A1.

**OTHER COMMENTS:** used as a chemical intermediate for fatty acids, soaps, lubricants, plasticizers, rubber-like compounds, and pesticides; chemical intermediate for pharmaceuticals (e.g., fat-soluble vitamins); has also been used in paints (as drying oils), shortenings, salad dressings, margarine, rubber softeners, and dietary supplements; useful as a cosmetic ingredient (e.g., moisturizers and lipsticks) and as a pharmaceutical ingredient (e.g., skin care oils and derivatives).

**KEY REFERENCES:** 3; 4; 5; 6; 7; 15.

## VINYL CHLORIDE (CH<sub>2</sub>=CHCl, 62.50)

**CAS/DOT IDENTIFICATION #:** 75-01-4/UN1086

**SYNONYMS:** chloroethane, chloroethylene, ethylene monochloride, monochloroethene, monochloroethylene, vc, vinyl chloride monomer.

**PHYSICAL PROPERTIES** : colorless gas or liquid; pleasant, sweet odor at high concentrations; liquid below 7°F (-14°C); soluble in alcohol, ether, carbon tetrachloride, and benzene; slightly soluble in water; MP (-154°C, -245°F); BP (-14°C, 7°F); DN (0.9195 g/mL at 15°C); LSG (0.91); HV (18.64 kJ/mol at 25°C); VD (2.16); VP (2530 mmHg at 20°C, 2600 mmHg at 25°C).

**CHEMICAL PROPERTIES**: flammable; polymerizes in light or in presence of catalyst; may be stabilized by inhibitors such as phenol; attacks iron and steel in presence of moisture; reacts with aluminum, aluminum alloys, or copper; FP (-78°C, -108°F); LFL/UFL (3.6%, 33.0%); AT (472°C, 882°F).

**EXPLOSION and FIRE CONCERNS**: highly flammable; NFPA rating Health 2, Flammability 4, Reactivity 2; very dangerous fire hazard; large fires of this material are practically inextinguishable; severe explosion hazard in vapor form when subjected to heat or flame; flashback along vapor trail may occur; hazardous polymerization may occur; polymerization may be initiated by air, sunlight, elevated temperature, oxidizing materials, and peroxides; reacts vigorously with oxidizing materials; explodes on contact with oxides of nitrogen; closed containers may rupture violently when heated; combustion by-products include highly toxic fumes of hydrogen chloride and carbon monoxide; use water spray, dry chemical, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (headache, dizziness, giddiness, irritation to eyes, irritation to upper respiratory tract, and skin burns); contact (liquid causes frostbite damage).

**FIRST AID**: wash eyes immediately with large amounts of water; flush skin immediately with large amounts of water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA**: inhalation-man TCLo 30 mg/m<sup>3</sup>; toxic effect: reproductive effect; inhalation-man TCLo 200 pm/14Y-I; toxic effect: carcinogenic effects, liver; inhalation-human TCLo 300 mg/m<sup>3</sup>/W -C; toxic effect: carcinogenic effects, blood effects; cytogenetic analysis-human HeLa cell 10 mmol/L.

**ACUTE HEALTH RISKS**: irritation of skin, eyes, and mucous membranes; irritation to upper respiratory tract; weakness; abdominal pain; gastrointestinal bleeding; hepatomegaly; pallor; cyanosis of extremities; anesthesia; narcosis; central nervous system depression; loss of consciousness; liquid causes frostbite damage.

**CHRONIC HEALTH RISKS**: liver injury; circulatory and bone changes in the fingertips; thickening of skin; changes in blood; increased incidence of birth defects; effects on the lungs; increased incidence of birth defects; "vinyl chloride disease"; brain cancer; cancer of the lung; cancer of the digestive tract; EPA group A: human carcinogen.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 5 ppm; ACGIH TLV STEL 25.6 mg/m<sup>3</sup>; OSHA PEL TWA 1 ppm; OSHA PEL CL 5 pmm (12.8 mg/m<sup>3</sup>); NIOSH REL lowest detectable level.

**PERSONAL PROTECTION**: wear rubber boots, apron and chemical-resistant gloves; wear positive pressure self-contained breathing apparatus equipped with full face piece; wear chemical safety goggles.

**SPILL CLEAN-UP**: use water spray to cool or disperse vapors; absorb liquid with non-combustible materials (e.g. dry earth, sand or vermiculite), and place in chemical waste containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS**: absorb in sand or inert absorbent, and place in a secured sanitary landfill; store in a cool, dry location with adequate ventilation; outside stor-

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age is preferred; inside storage should be in a standard flammable liquids storage room or cabinet; separate from strong oxidizers and peroxides.

**REGULATORY INFORMATION:** CA2; S1; S32-4; S50-a2; S61-a1; S62'-8; R1; R2-61; F3;R4; R5; R7; R8; D waste # (D043); U waste # (U043); Reportable Quantity (RQ): 1 lb (0.454 kg); Sfl; Sfg; CW3; CW4; CW5; A1; A4; CAL; DOT hazard class/division (2.1); labels (flammable gas).

**OTHER COMMENTS:** used in the plastics industry; used as a refrigerant; used in the manufacture of polyvinyl chloride, vinyl products, and other organic compounds.

**KEY REFERENCES:** 2; 3; 4; 5; 6; 7; 10; 12; 13; 14; 19.

### VINYL TOLUENE ( $\text{CH}_2=\text{CHC}_6\text{H}_4\text{CH}_3$ , 118.19).

**CAS/DOT IDENTIFICATION #:** 25013-15-4/UN2618

**SYNONYMS:** ethenylmethylbenzene, methylstyrene, tolyethylene.

**PHYSICAL PROPERTIES :** colorless liquid; strong, disagreeable odor; soluble in methanol, ether, acetone, carbon tetrachloride, benzene, diethyl ether, n-heptane, and ethanol; very slightly soluble in water; MP (-77°C, -107°F); BP (168°C, 334°F); DN (0.890 g/mL at 25°C); LSG (0.89); ST (31.66 dynes/cm at 20°C); VS (0.837 cP); CP (1.2284 J/g-K gas at 25°C); HV (426.10 J/g at 25°C, 349.24 J/g at 168°C); VD (4.1 at 168°C); VP (1.1 mmHg at 20°C); OT (240 mg/m<sup>3</sup>).

**CHEMICAL PROPERTIES:** combustible liquid; reacts vigorously with acids, oxidizing materials; peroxides, polymer initiators, and metal salts such as iron chloride or aluminum chloride; usually contains inhibitors, such as tert-butyl catechol, to prevent polymerization; pure vapor will be uninhibited and may polymerize; FP (53°C, 127°F); LFL/UFL (0.8%, 11.0%); AT (494°C, 921°F); HC (4,816.54 kJ/mol gas at 25°C); HF (115.48 kJ/mol liquid at 25°C); HP (66.9 or -0.2 kJ/mol).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating Health 2, Flammability 2, Reactivity 2; may accumulate static electricity; can polymerize and explode in the container; pure vapor will be uninhibited and may polymerize in confined spaces; closed containers may rupture violently when heated; contact with oxidizing agents may cause fires and explosions; incompatible with strong acids, peroxides, and aluminum chloride; toxic gases and vapors, such as carbon monoxide, may be released in a fire; use dry chemical, carbon dioxide, foam, or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, nose, throat, and skin); skin absorption (central nervous system depression, nausea, dizziness, narcotic effects); contact (defatting of skin, dermatitis).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 400 ppm; toxic effect: nose, eyes.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory system; dizziness; weakness; drowsiness; nausea; narcosis; loss of consciousness.

**CHRONIC HEALTH RISKS:** depression of central nervous system; fatigue; defatting of skin causing dermatitis; exacerbation of impaired pulmonary function; psychic reflex bronchospasm.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 50 ppm; ACGIH STEL 100 ppm; OSHA PEL TWA 100 ppm (480 mg/m<sup>3</sup>); NIOSH REL TWA 100 ppm (480 mg/m<sup>3</sup>); IDLH 400 ppm.

**PERSONAL PROTECTION:** wear appropriate chemical protective gloves, boots, aprons, etc.; use splash-proof safety goggles; appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL).

**SPILL CLEAN-UP:** ventilate area of spill or leak; use water spray to cool and disperse vapors; absorb large quantities of liquid in noncombustible materials such as dry earth, sand or vermiculite; flush remaining vinyl toluene with large amounts of water but not into spaces such as sewers because of danger of explosion; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite and place in a secured sanitary landfill; atomize large quantities in a suitable combustion chamber; dissolve in a flammable liquid and burn in incinerator equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; store away from sunlight, heat, oxidizing materials, peroxides, and metal salts; outside storage is preferred.

**REGULATORY INFORMATION:** T30-e10; T120-d10; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used during the application of specialty paints and varnishes; used during spray applications of vinyl toluene polyester surface coatings; chemical intermediate for unsaturated polyester resins; useful in the preparation of copolymers with drying oils for surface coatings.

**KEY REFERENCES:** 4; 5; 6; 7; 8; 10; 11; 12; 16.

### **WARFARIN (C<sub>19</sub>H<sub>16</sub>O<sub>4</sub>, 308.35)**

**CAS/DOT IDENTIFICATION #:** 81-81-2/NA

**SYNONYMS:** 3-( $\alpha$ -acetylbenzyl)-4-hydroxycoumarin, 4-hydroxy-3-(3-oxo-1-phenylbutyl)-2H-1-benzopyran-2-one, warf.

**PHYSICAL PROPERTIES :** colorless, crystalline powder; odorless; tasteless; has an acidic enol, a ketone, and a 2,4-dinitrophenylhydrazone; soluble in acetone and dioxane; moderately soluble in methanol, ethanol, isopropanol, and some oils; very soluble in alkaline aqueous solutions; practically insoluble in water, benzene, and cyclohexane; MP (161°C, 322°F); BP (decomposes); DN (NA); SG (NA); ST (NA); VS (NA); CP (NA); HV (NA); VD (NA); VP (9 x 10<sup>-2</sup> mbar at 21.5°C); OT (NA).

**CHEMICAL PROPERTIES:** combustible solid; very stable, even to strong acids; non-corrosive; has an acidic enol that forms metallic salts, and an acetate and a ketone that forms an oxime; forms a water-soluble sodium salt in alkaline aqueous solution; reacts with strong oxidizers; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (NA); H<sub>f</sub> (NA).

**EXPLOSION and FIRE CONCERNS:** combustible; NFPA rating (NA); contact with strong oxidizers may cause fires and explosions; toxic gases and vapors, such as carbon monox-

ide, may be released in a fire; use foam, carbon dioxide, and dry chemical for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (back pain, nosebleed); ingestion (hemorrhage, blood in urine, fecal blood, abdominal pain, vomiting, bleeding from small intestine, blood clotting factor change, physical abnormalities at birth, fetal death); contact (petechial rash).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** oral-human LDLo 6667 $\mu\text{g}/\text{kg}$ ; oral-man TDLo 10.2 mg/kg; toxic effect: blood; oral-woman TDLo 15mg/kg/21W; toxic effect: gastrointestinal tract; oral-woman TDLo 33,600 $\mu\text{g}/\text{kg}$  (1-32W pregnancy); toxic effect: reproductive effects.

**ACUTE HEALTH RISKS:** hematuria; back pain; hematoma of arms and legs; epistaxis (nosebleed); bleeding lips and mucous membrane hemorrhage; abdominal pain; vomiting; fecal blood; petechial rash; ulceration or bleeding from small intestine; blood clotting factor change.

**CHRONIC HEALTH RISKS:** human reproductive effects; physical abnormalities at birth; fetal death; human teratogenic effects; developmental abnormalities of the craniofacial area; developmental abnormalities of the musculoskeletal system; respiratory system abnormalities; other reproductive effects.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.1 mg/m<sup>3</sup>; OSHA PEL TWA 0.1 mg/m<sup>3</sup>; NIOSH REL TWA 0.1mg/m<sup>3</sup>; IDLH 100 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** use impervious clothing, gloves, and face shields; dust- and splash-proof safety goggles; wear positive pressure self-contained breathing apparatus.

**SPILL CLEAN-UP:** ventilate area of spill or leak; sweep small quantities onto paper or other suitable material, place in an appropriate container and cautiously burn in a fume hood; dissolve large quantities in a flammable solvent, such as alcohol and atomize in a suitable combustion chamber.

**DISPOSAL AND STORAGE METHODS:** prepare packages of warfarin in paper or other flammable materials and burn in a suitable combustion chamber; dissolve in a flammable solvent, such as alcohol, and atomize in a suitable combusting chamber; place in closed containers for storage; should be kept well separated from oxidizing agents (nitrates, peroxides, etc.); should not be stored near combustible materials.

**REGULATORY INFORMATION:** R4; R6; Reportable Quantity (RQ): 100 lbs. (45.4 kg); Sf2; A1; CAL.

**OTHER COMMENTS:** used as a rodenticide; used as an oral anticoagulant.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 12; 14.

### **XYLENES (o-, m-, p-isomers) (C<sub>8</sub>H<sub>10</sub>, 106.18)**

**CAS/DOT IDENTIFICATION #:** 1330-20-7/UN1307

**SYNONYMS:** 1,2-dimethylbenzene, 1,3-dimethylbenzene, 1,4-dimethylbenzene, dimethylbenzene, methyl toluene, xylol.

**PHYSICAL PROPERTIES** : clear, colorless liquid; sweet, aromatic odor; miscible with absolute alcohol, ether, and many other organic liquids; MP (ortho-25°C, -13°F; meta -48°C, -54°F; para 13°C, 55°F); BP(ortho 144°C, 291°F; meta 139°C, 282°F; para 137°C, 279°F); DN (0.864 g/mL at 20°C); LSG (0.87); ST (ortho-29.76, meta 28.47, para 28.01 mN/m at 25°C); VS (ortho 0.760, meta 0.581, para 0.603 mPa-s at 25°C): CP (ortho 186.1, meta 183.0, para 181.5 J/K-mol liquid at 25°C): HV (ortho 43.43, meta 42.65, para 42.4 kJ/mol at 25°C); VD(3.70); VP (6.72 mmHg at 21°C); OT(5.00 x 10<sup>-5</sup> ppm).

**CHEMICAL PROPERTIES:** flammable liquid; can be easily chlorinated, sulfonated, or nitrated; very corrosive; will attack some forms of plastics, rubber, and coatings; reacts with strong acids and oxidizing materials; FP (ortho 17°C, 63°F; meta 25°C, 77°F; para 25°C, 77°F); LFL/UFL (ortho 0.9%, 6.7%; meta 1.1%, 7.0%; para 1.1%, 7.0%); AT (ortho 463°C, 867°F; meta 527°C, 982°F; para 528°C, 984°F); HF(ortho -24.4, meta -25.4, para -24.4 kJ/mol liquid at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable liquid; NFPA rating Health 2, Flammability 3, Reactivity 0; very dangerous fire hazard; flashback along vapor trail may occur; liquid floats on water; may travel to an ignition source and spread fire; reacts strongly with oxidizing agents and rubber; forms explosive mixtures in air; may accumulate static electricity; decomposition may produce irritants and toxic fumes; use water spray, dry chemical, foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (olfactory changes, pulmonary changes, conjunctive irritation, dizziness, excitement, staggering gait, drowsiness, nausea, vomiting, narcotic effects); absorption (pulmonary edema, chemical pneumonitis, hemorrhage); ingestion (severe gastrointestinal distress); contact (eye irritation, conjunctivitis, corneal burns, dermatitis due to defatting action).

**FIRST AID:** wash eyes immediately with large amounts of water; wash skin immediately with soap and water; provide oxygen and respiratory support.

**HUMAN TOXICITY DATA:** eye-human 200ppm; oral-human LDLo 50mg/kg; inhalation-man LCLo 10,000ppm/6H; inhalation-human TCLo 200ppm; toxic effect: nose, eye, pulmonary system; oral-unspecified LD<sub>50</sub> 4300 mg/kg; inhalation-unspecified LC<sub>50</sub> 30g/m<sup>3</sup>.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and upper respiratory system; narcotic effects; flushing and reddening of the face; dilation of superficial blood vessels causing a feeling of increased heat; disturbed vision; dizziness; tremors; salivation; cardiac stress; drowsiness; incoordination; staggering gait; central nervous system depression; nausea; vomiting; pulmonary edema; chemical pneumonitis; confusion; coma.

**CHRONIC HEALTH RISKS:** respiratory irritation; central nervous system excitation; central nervous system depression; paresthesia; tremors; apprehension; impaired memory; weakness; vertigo; headache; anorexia; nausea; anemia; mucosal hemorrhage; nervous irritation; ringing in the ears; excessive fatigue; chronic bronchitis; liver, kidney, and nerve damage.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 100ppm; ACGIH TLV STEL 150 ppm; OSHA PEL TWA 100ppm (435 mg/m<sup>3</sup>); OSHA PEL STEL 150 ppm; NIOSH REL TWA 100ppm (435mg/m<sup>3</sup>); NIOSH REL STEL 150 ppm (655 mg/m<sup>3</sup>); NIOSH REL CL 200ppm/10m; IDLH 900ppm.

**PERSONAL PROTECTION:** wear impervious clothing, chemical-resistant gloves, and face shields; wear chemical safety goggles; wear self-contained breathing apparatus operated in a positive pressure mode.

**SPILL CLEAN-UP:** use appropriate foam to blanket release and suppress vapors; absorb small quantities on paper towels and evaporate in a fume hood; atomize large amounts in a suitable combustion chamber equipped with effluent gas cleaning device; remove all ignition sources.

**DISPOSAL AND STORAGE METHODS:** absorb as much as possible with noncombustible materials such as dry earth or sand, and place in a sanitary landfill; flush remaining xylenes with large amounts of water but not into confined spaces such as sewers because of danger of explosion; atomize large amounts in a suitable combustion chamber; store in a cool, dry location; keep containers tightly closed, away from heat, sparks, and open flame; storage should be inside a standard flammable liquid storage room or cabinet; separate from strong oxidizers, nitric acid, and acetic acid.

**REGULATORY INFORMATION:** CA2; S1; S32-52; S10; F2; R2-62; R5; R6; U waste # (U239); Reportable Quantity (RQ): 100 lbs (45.4 kg); Sf1; Sf3; CW1; CW2; A1; CAL; DOT hazard class/division (3); labels (flammable liquid).

**OTHER COMMENTS:** used in manufacturing dyes, resins, paints, and varnishes; used in manufacture of quartz crystal oscillators, hydrogen peroxide, perfumes, insect repellants, epoxy resins, and pharmaceuticals; general solvent for adhesives, paints, coatings, and rubber; raw material for the production of benzoic acid, phthalic anhydride, isophthalic and terephthalic acids; used in the production of their dimethyl esters; used in the manufacture of polyester fibers; also used in the leather industry.

**KEY REFERENCES:** 3; 4; 5; 6; 8; 10; 11; 12; 13; 14; 19.

### **XYLIDINE ((CH<sub>3</sub>)<sub>2</sub>C<sub>6</sub>H<sub>3</sub>NH<sub>2</sub>, 121.2)**

**CAS/DOT IDENTIFICATION #:** 1300-73-8/UN1711

**SYNONYMS:** aminodimethylbenzene, aminoxylene, dimethylaminobenzene, dimethylaniline, xylidene isomers (e.g., 2,4-dimethyl-aniline).

**PHYSICAL PROPERTIES :** pale-yellow to brown liquid; weak, aromatic, amine-like odor; soluble in alcohol and ether; slightly soluble in water; MP (NA); BP (213-226°C, 415-439°F); DN (0.97-0.99); LSG (0.98 at 20°C); VD (4.17); VP (< 1 mmHg at 20°C); OT (0.0048 ppm).

**CHEMICAL PROPERTIES:** combustible liquid; heat may contribute to instability; forms more or less soluble salts with strong mineral acids; can react vigorously with oxidizing materials; will attack some forms of plastics, rubber and coatings. FP (96.7°C, 206°F); LFL/UFL (1.5%, NA); AT (NA).

**EXPLOSION and FIRE CONCERNS:** combustible when exposed to heat or flame; NFPA rating (NA): contact with strong oxidizers may cause fires and explosion; contact with hypochlorite bleaches may form explosive chloroamines; toxic gases and vapors, such as oxides of nitrogen and carbon monoxide, may be released in a fire; use carbon dioxide, dry chemical, or foam for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (anoxia, cyanosis, methemoglobinemia); skin absorption (headache, nausea, liver and kidney damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large amounts of water and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** bluish discoloration of the skin, especially the lips; drowsiness; headache; nausea; vomiting; loss of consciousness; death.

**CHRONIC HEALTH RISKS:** damage to the liver and kidneys; lung damage; methemoglobinemia; injury to the blood.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 0.5 ppm(skin); OSHA PEL TWA 5 ppm (25mg/m<sup>3</sup>)(skin); NIOSH REL TWA 2 ppm (10 mg/m<sup>3</sup>)(skin); IDLH 50ppm.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); use impervious clothing and chemical-resistant gloves; use splash-proof safety goggles; facilities for quick drenching of the body and an eye-wash fountain should be provided within immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; absorb small quantities on paper towels and evaporate in a fume hood; atomize large quantities in a suitable combustion chamber; absorb as much as possible in noncombustible materials such as dry earth, sand, or vermiculite.

**DISPOSAL AND STORAGE METHODS:** absorb in dry earth, sand or vermiculite and place in a secured, sanitary landfill; atomize large amounts in a suitable combustion chamber equipped with appropriate effluent gas cleaning device; store in a cool, dry location with adequate ventilation; keep away from strong oxidizers and hypochlorite salts.

**REGULATORY INFORMATION:** T30-e10; T120-d10; CAL; DOT hazard class/division (6.1); labels (poison).

**OTHER COMMENTS:** used chiefly in the manufacture of dyes; used as a gasoline additive and in the manufacture of detergents and antiknock agents; useful in organic synthesis, in the manufacture of pharmaceuticals, and in polymer production.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 16.

## YTTRIUM (Y, 88.9)

**CAS/DOT IDENTIFICATION #:** 7440-65-5/NA

**SYNONYMS:** yttrium-89, yttrium metal.

**PHYSICAL PROPERTIES :** silvery-metallic, lustrous solid; darkens on exposure to light; forms hexagonal close-packed crystals; brittle; much harder than zinc; soluble in dilute acids and potassium hydroxide solution; odorless; MP (1522°C, 2772°F); BP (3338°C, 6040°F); DN (4.469 g/cm<sup>3</sup>); SG (4.47); CP (26.5 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg at 20°C).

**CHEMICAL PROPERTIES:** noncombustible solid; reasonably air-stable; oxidizes on heating in air or oxygen; reacts slowly with cold water; rapid reaction with dilute acid; reacts with chlorine at 2°C and oxygen at 4°C; decomposes cold water slowly, boiling water rapidly; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (0.0 kJ/mol at 25°C); H<sub>f</sub> (11.43 kJ/mol at 1799K); HS (424.7 kJ/mol at 25°C).

**EXPLOSION and FIRE CONCERNS:** flammable in form of dust when reacted with air and halogens; NFPA rating (NA); burns easily; incompatible with strong oxidizers; contact with combustible materials may cause fires and explosions; toxic gases and vapors, such as carbon monoxide, may be released in a fire.

**HEALTH SYMPTOMS:** inhalation (irritates eyes, pulmonary irritation); contact (eye injury, possible liver damage).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes; chemical eye damage; pulmonary irritation; breathing difficulty.

**CHRONIC HEALTH RISKS:** possible liver damage; increased risk of lung damage and chronic respiratory disease; may have anticoagulant effect on the blood.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA  $1\text{mg(Y)}/\text{m}^3$ ; OSHA PEL TWA  $1\text{mg(Y)}/\text{m}^3$ ; NIOSH REL TWA  $1\text{mg(Y)}/\text{m}^3$ (skin); IDLH  $500\text{mg(Y)}/\text{m}^3$ .

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); wear impervious clothing and chemical-resistant gloves; use dust- and splash-proof safety goggles; an eye-wash fountain should be provided within immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; collect spilled material in a safe manner and package in sealed containers; absorb liquid containing yttrium in dry earth, sand, or vermiculite.

**DISPOSAL AND STORAGE METHODS:** dispose of in sealed containers in a secured landfill; absorb in dry earth, sand or vermiculite and dispose of in a secured sanitary landfill; store in a suitably protected and well-ventilated interior area at ambient temperatures; keep away from oxidizing agents and combustible materials.

**REGULATORY INFORMATION:** A1.

**OTHER COMMENTS:** used in the manufacture of red phosphorus used in color television receivers; use as electronic components in telephones, radar and space communications networks; may also be used in the manufacture of simulated diamonds.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 16.

## **ZINC CHLORIDE FUME ( $\text{ZnCl}_2$ , 136.27)**

**CAS/DOT IDENTIFICATION #:** 7646-85-7/UN1840 (solid)

**SYNONYMS:** zinc dichloride fume

**PHYSICAL PROPERTIES :** white particulate dispersed in air; acrid odor; solid is soluble in methanol, ethanol, diethyl ether, and acetone; very soluble in water; MP ( $290^\circ\text{C}$ ,  $554^\circ\text{F}$  for solid); BP ( $732^\circ\text{C}$ ,  $1350^\circ\text{F}$  for solid); DN ( $2.907\text{ g}/\text{cm}^3$  solid at  $25^\circ\text{C}$ ); SG ( $2.91$  solid); VD (NA); VP ( $0\text{ mmHg}$  approximately); OT (NA).

**CHEMICAL PROPERTIES:** noncombustible; fume is corrosive to metals; fume can react vigorously with potassium; in weak aqueous solution tends to form an insoluble basic salt by hydrolysis; with much water, forms some zinc oxychloride; FP (NA); LFL/UFL (NA); AT (NA); HC (NA).

**EXPLOSION and FIRE CONCERNS:** not combustible; fumes are highly toxic; incompatible with potassium; mixtures of powdered zinc and powdered chloride are flammable; heating the solid to decomposition emits toxic fumes of chloride and zinc oxide; use agent suitable for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (nausea, sore throat, chest tightness, tachypnea, substernal soreness, fever, cyanosis, conjunctivitis, coma, irritates eyes, mucous membranes, and skin).

**FIRST AID:** provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-man T<sub>CLo</sub> 4800 mg/m<sup>3</sup>/30M; toxic effect: pulmonary effects; inhalation-human T<sub>CLo</sub> 4800 mg/m<sup>3</sup>/3H.

**ACUTE HEALTH RISKS:** irritation of eyes, skin, nose and throat; shortness of breath; constriction in the chest; abdominal pain; watering of eyes; burning of eyes and throat; coughing with phlegm and bloody sputum; blue discoloration of skin and lips; pulmonary edema; nausea; substernal pain; epigastric pain; fever; bronchopneumonia; coma.

**CHRONIC HEALTH RISKS:** dermatitis; boils; gastrointestinal tract upsets; fibroblastic proliferation of lungs; cor pulmonale; death.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 1 mg(fume)/m<sup>3</sup>; ACGIH TLV STEL 2 mg(fume)/m<sup>3</sup>; OSHA PEL TWA 1mg(fume)/m<sup>3</sup>; NIOSH REL TWA 1 mg(fume)/m<sup>3</sup>; NIOSH REL STEL 2 mg(fume)/m<sup>3</sup>; IDLH 50 mg(fume)/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear rubber aprons, rubber gloves, gauntlets, suits, and rubber boots; chemical safety goggles are recommended; wear self-contained breathing apparatus operated in positive pressure mode.

**SPILL CLEAN-UP:** restrict persons not wearing protective equipment and clothing from areas of release until cleanup has been completed; ventilate area of the release to disperse the fume.

**DISPOSAL AND STORAGE METHODS:** NA

**REGULATORY INFORMATION:** Sfl; CW1; CW2; A1; CAL.

**OTHER COMMENTS:** liberated from petroleum refining operations; liberated from solutions in glass and metal etching, from the manufacture of dry cell batteries, and from vulcanizing and reclaiming processes for rubber.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 11; 16.

## ZINC OXIDE FUME (ZnO, 81.37)

**CAS/DOT IDENTIFICATION #:** 1314-13-2/UN 1516

**SYNONYMS:** amalox, azo-33, permanent white, snow white, zinc peroxide, zinc white, zincite, zincoid.

**PHYSICAL PROPERTIES** : white or yellowish-white powder, or hexagonal crystals; odorless; bitter taste; soluble in dilute acetic or mineral acids, ammonia, ammonium carbonate, and fixed alkali hydroxide solutions; soluble in ammonium chloride; insoluble in water and alcohol; has greatest UV absorption of all commercial pigments; opaque to all wavelengths of light; when strongly heated, assumes a yellow color which disappears on cooling; MP (1975°C, 3587°F); BP (solid sublimates at 760 mmHg); DN (5.607 g/cm<sup>3</sup> at 20°C); SG (5.61); CP (40.26 J/mol·°C at 25°C); VD (NA); VP (0 mmHg approximately); IR (2.0041, 2.0203).

**CHEMICAL PROPERTIES**: noncombustible solid; gradually absorbs carbon dioxide upon exposure to air; reacts with hydrochloric acid to produce zinc chloride; reacts with sulfuric acid to produce zinc sulfate, and it reacts with carbon monoxide or hydrogen to produce elemental zinc; reacts lowly with fatty acids in oils and fats to produce lumpy masses of zinc oleate, stearate, etc.; forms cement-like products when mixed with a strong solution of zinc chloride or with phosphoric acid, owing to the formation of oxy-salts; hydrogen peroxide is produced when ointments containing zinc oxide and water are melted and exposed to UV light; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-350.5 kJ/mol crystal at 25°C); pH (6.95 American process zinc oxide, 7.37 French process zinc oxide).

**EXPLOSION and FIRE CONCERNS**: not combustible; NFPA rating (NA); forms a violent reaction with magnesium; slow addition to cover the surface of linseed oil varnish may cause generation of heat and ignition; reacts violently with chlorinated rubber at 215°C (419°F); slowly decomposed by water; reacts with hydrogen fluoride to produce zinc fluoride tetrahydrate; heating to decomposition emits toxic fumes of zinc oxide; use dry chemical, carbon dioxide, alcohol-resistant foam or water spray for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (fever, chills, myalgias, vomiting, prostration, pulmonary edema, respiratory irritation); contact (lacrimation, photophobia, pain, swelling, irritation); ingestion (nausea, vomiting, headache, chills, fever, malaise, abdominal pain, copper and iron deficiency).

**FIRST AID**: wash eyes immediately with large amounts of water; wash or shower immediately on skin contact with zinc oxide fume; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA**: inhalation-human TCLo 600 mg/m<sup>3</sup>; toxic effect: lung, thorax, or respiration; oral-human LDLo 500 mg/kg.

**ACUTE HEALTH RISKS**: flu-like illness called metal fume fever; metallic taste in mouth; headache; aches; chills; fever; cough; shortness of breath; chest pains; nausea; vomiting; weakness; tiredness; drying and irritation of the throat; low back pain; muscle cramps; blurred vision; reversible reduction in pulmonary vital capacity.

**CHRONIC HEALTH RISKS**: development of dermatitis; boils; conjunctivitis; gastrointestinal disturbances; may damage developing fetus.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 5 mg(fume)/m<sup>3</sup>; ACGIH TLV STEL 10 mg(fume)/m<sup>3</sup>; ACGIH TLV TWA 10 mg (total dust)/m<sup>3</sup>; OSHA PEL TWA 5 mg(fume)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 5 mg(fume/total dust)/m<sup>3</sup>; NIOSH REL STEL 10mg(fume)/m<sup>3</sup>; NIOSH REL CL 15 mg(total dust)/m<sup>3</sup>; IDLH 500mg/m<sup>3</sup>.

**PERSONAL PROTECTION**: wear full protective clothing (suits, gloves, footwear, headgear); wear dust-proof safety goggles and face shield when working with powders or dust; wear positive pressure self-contained breathing apparatus; adequate ventilation should be provided in all cases where zinc is heated to the point where fume is produced.

**SPILL CLEAN-UP:** ventilate area of release to disperse zinc oxide fume; use a vacuum or a wet method to reduce dust during clean-up; do not dry sweep; absorb or cover with dry earth, sand or other non-combustible material and transfer to containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in an approved sanitary landfill in accordance with local regulations; may be necessary to contain and dispose of zinc oxide fume as a hazardous waste; consult with environmental regulatory agencies for guidance on acceptable disposal practices; store in airtight containers; avoid contact with chlorinated rubber, magnesium and linseed oil since violent reactions occur.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** zinc oxide is incorporated in powders, ointments, and pastes; it is also incorporated into calamine lotion; used in floor covering, fabrics, lubricants, plastics, and rayon manufacture; used as a pigment in white paint instead of lead carbonate; use in cosmetics, driers, quick-setting cements, dusting powder, carbon black mixtures, in dental disclosing waxes, and as an anti-caking agent; useful as an accelerator activator and reinforcing agent in rubber, a pigment and mold growth inhibitor in paints, and as a feed additive and dietary supplement; has been used as a photoconductor in office copying machines and in color photography; zinc oxide fume may be released when welding galvanized metal; also liberated from use as an intermediate in the manufacture of other zinc compounds and in the manufacture of electronic devices; liberation from manufacture of glass to increase brilliance and luster of glass.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 15; 16.

## **ZINC OXIDE (ZnO, 81.37)**

**CAS/DOT IDENTIFICATION #:** 1314-13-2/UN 1516

**SYNONYMS:** amalox, azo-33, permanent white, snow white, zinc peroxide, zinc white, zincite, zincoid.

**PHYSICAL PROPERTIES :** white or yellowish-white powder, or hexagonal crystals; odorless; bitter taste; soluble in dilute acetic or mineral acids, ammonia, ammonium carbonate, and fixed alkali hydroxide solutions; soluble in ammonium chloride; insoluble in water and alcohol; has greatest UV absorption of all commercial pigments; opaque to all wavelengths of light; when strongly heated, assumes a yellow color which disappears on cooling; MP (1975°C, 3587°F); BP (solid sublimates at 760 mmHg); DN (5.607 g/cm<sup>3</sup> at 20°C); SG (5.61); CP (40.26 J/mol·°C at 25°C); VD (NA); VP (0 mmHg approximately); IR (2.0041, 2.0203).

**CHEMICAL PROPERTIES:** noncombustible solid; gradually absorbs carbon dioxide upon exposure to air; reacts with hydrochloric acid to produce zinc chloride; reacts with sulfuric acid to produce zinc sulfate, and it reacts with carbon monoxide or hydrogen to produce elemental zinc; reacts slowly with fatty acids in oils and fats to produce lumpy masses of zinc oleate, stearate, etc.; forms cement-like products when mixed with a strong solution of zinc chloride or with phosphoric acid, owing to the formation of oxy-salts; hydrogen peroxide is produced when ointments containing zinc oxide and water are melted and exposed to UV light; FP (NA); LFL/UFL (NA); AT (NA); HC (NA); HF (-350.5 kJ/mol crystal at 25°C); pH (6.95 American process zinc oxide, 7.37 French process zinc oxide).

**EXPLOSION and FIRE CONCERNS:** not combustible; NFPA rating (NA); forms a violent reaction with magnesium; slow addition to cover the surface of linseed oil varnish may

cause generation of heat and ignition; reacts violently with chlorinated rubber at 215°C (419°F); slowly decomposed by water; reacts with hydrogen fluoride to produce zinc fluoride tetrahydrate; heating to decomposition emits toxic fumes of zinc oxide; use dry chemical, carbon dioxide, alcohol-resistant foam or water spray for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (fever, chills, myalgias, vomiting, prostration, pulmonary edema, respiratory irritation); contact (lacrimation, photophobia, pain, swelling, irritation); ingestion (nausea, vomiting, headache, chills, fever, malaise, abdominal pain, copper and iron deficiency).

**FIRST AID:** wash eyes immediately with large amounts of water; wash or shower immediately on skin contact with zinc oxide fume; provide oxygen or respiratory support.

**HUMAN TOXICITY DATA:** inhalation-human TCLo 600 mg/m<sup>3</sup>; toxic effect: lung, thorax, or respiration; oral-human LDLo 500 mg/kg.

**ACUTE HEALTH RISKS:** flu-like illness called metal fume fever; metallic taste in mouth; headache; aches; chills; fever; cough; shortness of breath; chest pains; nausea; vomiting; weakness; tiredness; drying and irritation of the throat; low back pain; muscle cramps; blurred vision; reversible reduction in pulmonary vital capacity.

**CHRONIC HEALTH RISKS:** development of dermatitis; boils; conjunctivitis; gastrointestinal disturbances; may damage developing fetus.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5 mg(fume)/m<sup>3</sup>; ACGIH TLV STEL 10 mg(fume)/m<sup>3</sup>; ACGIH TLV TWA 10 mg (total dust)/m<sup>3</sup>; OSHA PEL TWA 5 mg(fume)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 5 mg(fume/total dust)/m<sup>3</sup>; NIOSH REL STEL 10mg(fume)/m<sup>3</sup>; NIOSH REL CL 15 mg(total dust)/m<sup>3</sup>; IDLH 500mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** wear full protective clothing (suits, gloves, footwear, headgear); wear dust-proof safety goggles and face shield when working with powders or dust; wear positive pressure self-contained breathing apparatus; adequate ventilation should be provided in all cases where zinc is heated to the point where fume is produced.

**SPILL CLEAN-UP:** ventilate area of release to disperse zinc oxide fume; use a vacuum or a wet method to reduce dust during clean-up; do not dry sweep; absorb or cover with dry earth, sand or other non-combustible material and transfer to containers; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** dispose of in an approved sanitary landfill in accordance with local regulations; may be necessary to contain and dispose of zinc oxide fume as a hazardous waste; consult with environmental regulatory agencies for guidance on acceptable disposal practices; store in airtight containers; avoid contact with chlorinated rubber, magnesium and linseed oil since violent reactions occur.

**REGULATORY INFORMATION:** A1; CAL.

**OTHER COMMENTS:** zinc oxide is incorporated in powders, ointments, and pastes; it is also incorporated into calamine lotion; used in floor covering, fabrics, lubricants, plastics, and rayon manufacture; used as a pigment in white paint instead of lead carbonate; use in cosmetics, driers, quick-setting cements, dusting powder, carbon black mixtures, in dental disclosing waxes, and as an anti-caking agent; useful as an accelerator activator and reinforcing agent in rubber, a pigment and mold growth inhibitor in paints, and as a feed additive and dietary supplement; has been used as a photoconductor in office copying machines and in color photography; zinc oxide fume may be released when welding galvanized metal; also liberated from use as an intermediate

in the manufacture of other zinc compounds and in the manufacture of electronic devices; liberation from manufacture of glass to increase brilliance and luster of glass.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 15; 16.

**ZINC STEARATE (Zn(C<sub>18</sub>H<sub>35</sub>O<sub>2</sub>)<sub>2</sub>, 632.20)**

**CAS/DOT IDENTIFICATION #:** 557-05-1/none

**SYNONYMS:** dibasic zinc stearate, octadecanoic acid zinc salt, stearic acid zinc salt, zinc distearate, zinc ocatadecanoate, zinc salt of stearic acid.

**PHYSICAL PROPERTIES :** fine, soft white powder, granules, prills or flakes; faint odor of fatty acid; hydrophobic (incapable of dissolving in water); insoluble in water, alcohol, and ether; slightly soluble in benzene; soluble in dilute acids; soluble in common solvents when hot; MP (120-130°C, 248-266°F); BP (decomposes); DN (1.095 g/cm<sup>3</sup>); SG (1.10); VD (NA); VP (0 mmHg approximately).

**CHEMICAL PROPERTIES:** stable under ordinary conditions of use and storage; hazardous polymerization will not occur; neutral reaction; repels water; decomposed by dilute acids; FP (279°C, 534°F); LFL/UFL (unknown); AT (790°C, 1454°F).

**EXPLOSION and FIRE CONCERNS:** combustible solid; NFPA rating Health 0, Flammability 1, Reactivity 0; contact with strong oxidizers may cause fire; sufficient concentrations of fine dust dispersed in air and in the presence of an ignition source is a potential dust explosion hazard; minimum dust cloud ignition temperature is 690°C (1274°F); minimum explosive concentration (MEC) is 0.02 g/L (air); maximum explosion pressure is 68 psi at 0.3 ounces per cubic foot; sensitive to static discharge; melted fatty acid can give "grease" type fire; pressure from fire extinguishing media may cause severe dusting; explosion hazards apply only to dusts, not to granular forms of this product; incompatible with strong oxidizers, strong alkalis, peroxides, oxygen, and dilute acids; burning may produce carbon monoxide, carbon dioxide, and toxic fumes of zinc oxide; use water spray, dry chemical, alcohol foam, or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (coughing, difficult breathing, blue discoloration of skin, pulmonary fibrosis, pulmonary edema, pneumonitis); skin contact (skin irritation, eczema); eye contact (redness, pain); ingestion (abdominal spasms, diarrhea).

**FIRST AID:** wash eyes thoroughly with running water; wash affected areas of the skin with plenty of soap and water; if breathing is difficult, remove to fresh air and get medical attention; if swallowed, drink several glasses of water and get medical advice.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of eyes, skin and upper respiratory system; coughing; difficulty breathing; abdominal spasms; diarrhea.

**CHRONIC HEALTH RISKS:** pneumonitis; cyanosis; pulmonary edema; pulmonary fibrosis; eczema.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 10 mg(total dust)/m<sup>3</sup>; OSHA PEL TWA 15mg(total dust)/m<sup>3</sup>, 5 mg(respirable fraction)/m<sup>3</sup>; NIOSH REL TWA 10 mg(total dust)/m<sup>3</sup>, 5mg(respirable fraction)/m<sup>3</sup>; IDLH (not determined).

**PERSONAL PROTECTION:** wear protective gloves, lab coat, apron or coveralls; use chemical safety goggles; a closed system of local exhaust ventilation is recommended to keep employee exposure below the Airborne Exposure Limits; a half-face dust/mist respirator is needed in areas where exposure would be above the permissible exposure level; in high vapor concentrations, use positive pressure self-contained breathing apparatus; use non-sparking tools and equipment.

**SPILL CLEAN-UP:** ventilate area of leak or spill; cautiously clean up spills in a manner that does not disperse dust into the air; reduce airborne dust and prevent scattering by moistening with water; pick up spill and place in a closed container; remove all sources of ignition.

**DISPOSAL AND STORAGE METHODS:** manage whatever cannot be saved for recovery or recycling in an approved waste disposal facility; dispose of container and unused contents in accordance with federal, state and local requirements; store in a cool, dry location; maintain adequate ventilation; keep in tightly closed containers and protect against physical damage; employ grounding, venting, and explosion relief provisions in storage area; avoid dust formation and control any ignition sources; isolate from incompatibles.

**REGULATORY INFORMATION:** A1; no transport information found, not regulated.

**OTHER COMMENTS:** used in cosmetic and pharmaceutical powders and ointments; useful as an agent for water-proofing concrete, rock, wool, paper and textiles; other uses include a drying lubricant, lacquers, dusting powder, tablet manufacture, dietary supplements, and a heat and light stabilizer.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 14.

### ZIROCNIUM COMPOUNDS (as Zr) (Zr, 91.224)

**CAS/DOT IDENTIFICATION #:** 7440-67-7/UN1358 (powder, wet), UN1932 (scrap), UN2008 (powder, dry)

**SYNONYMS:** zircoat, zirconium metal, zirconium powder, zirconium scrap; synonyms of other zirconium compounds vary depending upon the specific compound.

**PHYSICAL PROPERTIES :** bluish-black, amorphous powder or grayish-white lustrous metal; soft, malleable, ductile solid; hexagonal lattice below 865°C, body-centered cubic above 865°C; may become embrittled by the absorption of nitrogen, oxygen, and carbon; soluble in hot, very concentrated acids; insoluble in water and cold acids; MP (1857°C, 3375°F); BP (3577°C, 6471°F); DN (6.506 g/cm<sup>3</sup> at 20°C); SG (6.51); CP (25.4 J/K-mol crystal at 25°C); VD (NA); VP (0 mmHg at 20°C); BHN (85).

**CHEMICAL PROPERTIES:** most zirconium compounds are considered inert; zirconium metal can react with hydrofluoric acid, aqua regia, and hot phosphoric acid; attacked by fused potassium hydroxide or potassium nitrate; not attacked by cold, concentrated sulfuric or hydrochloric acid; resistant to attack by nitric acid; very resistant to corrosion; oxidizes rapidly at 6°C; nitrided slowly at 700°C; compact form combines with oxygen, nitrogen, carbon, and the halogens on prolonged heating; FP (NA); LFL/UFL (NA); AT (NA); HF (0.0 kJ/mol crystal at 25°C); H<sub>f</sub> (21.0 kJ/mol at 2127.85K).

**EXPLOSION and FIRE CONCERNS:** combustible, but solid form is difficult to ignite; powder form may ignite spontaneously and can continue burning under water; powder form is very explosive when mixed with oxidizing agents; dangerous explosion hazard in form of dust by chemical reaction with air, alkali hydroxides, alkali metal chromates, dichromates, sulfates,

molybdates, borax, tungstates, carbon tetrachloride, lead, lead oxide, copper oxide, phosphorus, potassium nitrate, potassium chlorate, and nitryl fluoride; explosive range reported as 0.16 g/L in air; use special mixtures, dry chemical, salt or dry sand for firefighting purposes.

**HEALTH SYMPTOMS:** inhalation (irritates mucous membranes of the respiratory tract, lung granulomas); contact (skin granulomas, x-ray evidence of pulmonary retention).

**FIRST AID:** wash eyes immediately with large amounts of water; wash affected areas of skin with plenty of soap and water; provide oxygen or respiratory support; if swallowed, drink large quantities of water immediately and induce vomiting.

**HUMAN TOXICITY DATA:** no toxicity data reported in humans.

**ACUTE HEALTH RISKS:** irritation of skin, eyes, and mucous membranes; x-ray evidence of retention in lungs.

**CHRONIC HEALTH RISKS:** lung granulomas; granulomas of the skin.

**EXPOSURE GUIDELINES:** ACGIH TLV TWA 5mg (Zr)/m<sup>3</sup>; ACGIH TLV STEL 10 mg(Zr)/m<sup>3</sup>; OSHA PEL TWA 5mg(Zr)/m<sup>3</sup>; NIOSH REL TWA 5 mg/m<sup>3</sup>; NIOSH REL STEL 10mg/m<sup>3</sup>; IDLH 50 mg/m<sup>3</sup>.

**PERSONAL PROTECTION:** appropriate respirators are needed in areas where exposure would be above the permissible exposure level (PEL); use impervious clothing and chemical-resistant gloves; use dust- and splash-proof safety goggles; facilities for quick drenching of the body and eye-wash fountain should be provided within immediate work area.

**SPILL CLEAN-UP:** ventilate area of spill; collect spilled material in a cautious manner and deposit in sealed containers; absorb as much as possible in noncombustible materials such as dry earth, sand or vermiculite.

**DISPOSAL AND STORAGE METHODS:** may be disposed of in sealed containers in a secured sanitary landfill; absorb in dry earth, sand or vermiculite, and place in a secured sanitary landfill; fine powder may be stored completely immersed in water; should not be stored near oxidizing agents and other combustible materials.

**REGULATORY INFORMATION:** Reportable Quantity (RQ): for most zirconium compounds is 5000 lbs (2270kg); A1; CAL; DOT hazard class/division (4.1); labels (flammable solid, UN1358), DOT hazard class/division (4.2); labels (spontaneously combustible, UN2008, UN1932).

**OTHER COMMENTS:** used in the manufacture of ceramics, glass, and porcelains; used in the synthesis of pigments, dyes, and water repellants; use as abrasive and polishing materials; use as an igniter in manufacture of explosives and other detonators, photoflash bulbs, and lighter flints; useful in the manufacture of skin ointments and antiperspirants; also used as a deoxidizer, denitrifier, and desulfurizer in iron and steel manufacture.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 8; 16.

## **METHYLENE DIANILINE (NH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>CH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>NH<sub>2</sub>, 198.29)**

**CAS/DOT IDENTIFICATION #:** 101-77-9/UN2651

**SYNONYMS:** p,p'-diaminodiphenylmethane, 4,4'-diaminodiphenylmethane, dianilinomethane, 4,4'-diphenylmethanediamine, 4,4'-methylenebisbenzenamine, mda.

**PHYSICAL PROPERTIES** : pale-yellow crystals or tan flakes from water or benzene; turns dark on exposure to air; faint, amine-like odor; very soluble in alcohol, benzene, and ether; slightly soluble in cold water; MP (92-93°C, 198-199°F); BP (398-399°C, 748-750°F at 768 mmHg); DN (1.06 g/mL liquid at 212°F); LSG (1.06 at 212°F); VP ( $2 \times 10^{-7}$  mmHg at 25°C, 0.012 mmHg at 100°C).

**CHEMICAL PROPERTIES**: stable under ordinary conditions of use and storage; hazardous polymerization will not occur; substance is a weak base; can react vigorously with strong oxidizers; FP (226.7°C, 440°F); LFL/UFL (unknown); AT (NA).

**EXPLOSION and FIRE CONCERNS**: combustible solid; NFPA rating Health 3, Flammability 1, Reactivity 0; reacts violently with strong oxidants; decomposes on heating or on burning producing toxic fumes of aniline and oxides of nitrogen; use powder, water spray, foam or carbon dioxide for firefighting purposes.

**HEALTH SYMPTOMS**: inhalation (abdominal pain, nausea, vomiting, cough, fever, chills); skin contact (dry skin, redness, skin sensitization, dermatitis); ingestion (rigidity, jaundice, damage to the liver).

**FIRST AID**: wash eyes immediately with large amounts of water for several minutes; rinse and then wash skin with plenty of soap and water; if breathing is difficult, remove to fresh air immediately and provide oxygen; provide respiratory support as indicated; if ingested, rinse mouth and get immediate medical attention.

**HUMAN TOXICITY DATA**: oral-man TDLo 8420µg/kg; toxic effect: central nervous system, liver.

**ACUTE HEALTH RISKS**: abdominal pain; nausea; vomiting; cough; fever; chills; anorexia; rigidity; weakness; may cause effects on the liver; jaundice; hepatitis; myocardial damage; irritation of skin and eyes.

**CHRONIC HEALTH RISKS**: may cause dermatitis; repeated or prolonged contact may cause skin sensitization; possible carcinogenic to humans; (may cause bladder cancer in animals); targets eyes, liver, cardiovascular system, and spleen.

**EXPOSURE GUIDELINES**: ACGIH TLV TWA 0.1 ppm (0.81 mg/m<sup>3</sup>)(skin); OSHA PEL TWA 0.010 ppm; OSHA PEL STEL 0.100 ppm; NIOSH REL TWA potential occupational carcinogen; IDLH not determined.

**PERSONAL PROTECTION**: wear impervious protective clothing, including boots, protective gloves, lab coat, apron or coveralls; use chemical safety goggles in combination with breathing protection; a system of local exhaust ventilation (not if powder) is recommended to control emissions at the source and to prevent dispersion into the general work area; use self-contained breathing apparatus in oxygen deficient atmospheres; maintain eyewash fountains and quick-drench facilities in work area.

**SPILL CLEAN-UP**: sweep spilled substance into sealable containers; carefully collect remainder, then remove to a safe place.

**DISPOSAL AND STORAGE METHODS**: whatever cannot be saved for recovery or recycling should be managed in an appropriate hazardous waste disposal facility; dispose of container and unused contents in accordance with federal, state, and local requirements; store in a cool, dry location; maintain adequate ventilation; separate from strong oxidants; store separately from food and feedstuffs.

**REGULATORY INFORMATION:** CA2; Reportable Quantity (RQ): 10 lbs (4.54 kg); Sf3; CAL; DOT hazard class/division (6.1); labels (keep away from food).

**OTHER COMMENTS:** used as an intermediate in the preparation of polyurethane foams, elastomeric fibers, and polyamides; used in industry as a curing agent for epoxy resins and urethane elastomers, and as a corrosion inhibitor for iron; useful in the determination of tungsten and sulfates; has also been used in the preparation of azo dyes, as a rubber processing chemical, and as an epoxy resin hardening agent.

**KEY REFERENCES:** 3; 4; 5; 6; 7; 12; 14; 19.

## APPENDIX A

### ALPHABETICAL LIST

As indicated in the Introduction, the regulated chemical entries are listed in the alphabetical order originally appearing in the applicable regulation with one exception. The seventeen Hazardous Air Pollutants, such as Antimony Compounds and Fine Mineral Fibers, which are categories or groups of chemicals for which no CAS number is available, have been integrated into the alphabetical order rather than being grouped at the end of the list as they are in the 1990 Amendments to the Clean Air Act. Also, numbers, letters (such as N or n), Greek letters, and prefixes such as sym, tris, ortho, meta and para that precede the name, do not affect the alphabetical order.

It is important to check the alphabetical list carefully as the use of two words for a name rather than one word could affect its location on the list. Names consisting of two or more words come before one word names. For example, methylene diphenyl diisocyanate would be found in a different location than 4-4'-methylenedianiline. The most common one word/two word variations of the names of the regulated chemicals, as well as many of their most common synonyms are listed in this Appendix. If the name of the chemical being sought is not found in this Appendix, it may be one of the many other possible synonyms. The reader may also choose to use the CAS Number Cross-Reference List (Appendix B) to locate the chemical. If the CAS # is not known, two good sources for locating synonyms and their corresponding CAS numbers are 1. Sax's Dangerous Properties of Industrial Materials, Richard J. Lewis, Van Nostrand Reinhold, 9<sup>th</sup> edition, 1996 (in 3 volumes), 2. Suspect Chemicals Sourcebook, Roytech Publications, Bethesda, Maryland, 1996 edition.

The names used for the regulated chemical entires follow.

#### HAZARDOUS AIR POLLUTANTS (HAPs)

Chemical or Trade Name	CAS No.
Acetaldehyde	75-07-0
Acetamide	60-35-5
Acetonitrile	75-05-8
Acetophenone	98-86-2
2-Acetylaminofluorene	53-96-3
Acrolein	107-02-8
Acrylamide	79-06-1
Acrylic acid	79-10-7
Acrylonitrile	107-13-1
Allyl chloride	107-05-1
4-Aminobiphenyl	92-67-1
Aniline	62-53-3
o-Anisidine	90-04-0
Antimony Compounds	Not available
Arsenic Compounds (inorganic including arsine)	Not available
Asbestos	1332-21-4
Benzene (including benzene from gasoline)	71-43-2
Benzidine	92-87-5

## HAZARDOUS AIR POLLUTANTS (HAPs)

Chemical or Trade Name	CAS No.
Benzotrichloride	98-07-7
Benzyl chloride	100-44-7
Beryllium Compounds	Not available
Biphenyl	92-52-4
Bis(2-ethylhexyl)phthalate (DEHP)	117-81-7
Bis(chloromethyl)ether	542-88-1
Bromoform	75-25-2
1,3-Butadiene	106-99-0
Cadmium Compounds	Not available
Calcium cyanamide	156-62-7
Captan	133-06-2
Carbaryl	63-25-2
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Carbonyl sulfide	463-58-1
Catechol	120-80-9
Chloramben	133-90-4
Chlordane	57-74-9
Chlorine	7782-50-5
Chloroacetic acid	79-11-8
2-Chloroacetophenone	532-27-4
Chlorobenzene	108-90-7
Chlorobenzilate	510-15-6
Chloroform	67-66-3
Chloromethyl methyl ether	107-30-2
Chloroprene	126-99-8
Chromium Compounds	Not available
Cobalt Compounds	Not available
Coke Oven Emissions	Not available
Cresols/Cresylic acid (isomers and mixture)	1319-77-3
o-Cresol	95-48-7
m-Cresol	108-39-4
p-Cresol	106-44-5
Cumene	98-82-8
Cyanide Compounds	Not available
2,4-D, Salts and Esters	94-75-7
DDE	72-55-9
Diazomethane	334-88-3
Dibenzofurans	132-64-9
1,2-Dibromo-3-chloropropane	96-12-8
Dibutylphthalate	84-74-2
1,4-Dichlorobenzene	106-46-7
3,3'Dichlorobenzidine	91-94-1
Dichloroethyl ether	111-44-4
1,3-Dichloropropene	542-75-6
Dichlorvos	62-73-7
Diethanolamine	111-42-2
N,N-Diethyl aniline	121-69-7

## HAZARDOUS AIR POLLUTANTS (HAPs)

Chemical or Trade Name	CAS No.
Diethyl sulfate	64-67-5
3,3'-Dimethoxybenzidine	119-90-4
Dimethyl aminoazobenzene	60-11-7
3,3'-Dimethyl benzidine	119-93-7
Dimethyl carbamoyl chloride	79-44-7
Dimethyl formamide	68-12-2
1,1-Dimethyl hydrazine	57-14-7
Dimethyl phthalate	131-11-3
Dimethyl sulfate	77-78-1
4,6-Dinitro-o-cresol, and salts	534-52-1
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
1,4-Dioxane	123-91-1
1,2-Diphenylhydrazine	122-66-7
Epichlorohydrin	106-89-8
1,2-Epoxybutane	106-88-7
Ethyl acrylate	140-88-5
Ethyl benzene	100-41-4
Ethyl carbamate	51-79-6
Ethyl chloride	75-00-3
Ethylene dibromide	106-93-4
Ethylene dichloride	107-06-2
Ethylene glycol	107-21-1
Ethyleneimine	151-56-4
Ethylene oxide	75-21-8
Ethylene thiourea	96-45-7
Ethylidene dichloride	75-34-3
Fine mineral fibers	Not available
Formaldehyde	50-00-0
Glycol ethers	Not available
Heptachlor	76-44-8
Hexachlorobenzene	118-74-1
Hexachlorobutadiene	87-68-3
Hexachlorocyclopentadiene	77-47-4
Hexachloroethane	67-72-1
Hexamethylene-1,6-diisocyanate	8220-6-0
Hexamethylphosphoramide	680-31-9
Hexane	110-54-3
Hydrazine	302-01-2
Hydrochloric acid	7647-01-0
Hydrogen fluoride	7664-39-3
Hydroquinone	123-31-9
Isophorone	78-59-1
Lead Compounds	Not available
Lindane (all isomers)	58-89-9
Maleic anhydride	108-31-6
Manganese Compounds	Not available

## HAZARDOUS AIR POLLUTANTS (HAPs)

Chemical or Trade Name	CAS No.
Mercury Compounds	Not available
Methanol	67-56-1
Methoxychlor	7-243-5
Methyl bromide	74-83-9
Methyl chloride	74-87-3
Methyl chloroform	71-55-6
Methyl ethyl ketone	78-93-3
Methyl hydrazine	60-34-4
Methyl iodide	74-88-4
Methyl isobutyl ketone	108-10-1
Methyl isocyanate	624-83-9
Methyl methacrylate	80-62-6
Methyl tert-butyl ether	1634-04-4
4,4'-Methylene bis(2-chloroaniline)	101-14-4
Methylene chloride	75-09-2
Methylene diphenyl diisocyanate	101-68-8
4,4'-Methylenedianiline	101-77-9
Naphthalene	91-20-3
Nickel Compounds	Not available
Nitrobenzene	98-95-3
4-Nitrobiphenyl	92-93-3
4-Nitrophenol	100-02-7
2-Nitropropane	79-46-9
N-Nitroso-N-methylurea	684-93-5
N-Nitrosodimethylamine	62-75-9
N-Nitrosomorpholine	59-89-2
Parathion	56-38-2
Pentachloronitrobenzene	82-68-8
Pentachlorophenol	87-86-5
Phenol	108-95-2
p-Phenylenediamine	106-50-3
Phosgene	75-44-5
Phosphine	7803-51-2
Phosphorus	7723-14-0
Phthalic anhydride	85-44-9
Polychlorinated biphenyls (PCB's)	1336-36-3
Polycyclic Organic Matter	Not available
1,3-Propane sultone	1120-71-4
beta-Propiolactone	57-57-8
Propionaldehyde	123-38-6
Propoxur	114-26-1
Propylene dichloride	78-87-5
Propylene oxide	75-56-9
1,2-Propylenimine	75-55-8
Quinoline	91-22-5
Quinone	106-51-4
Radionuclides (including radon)	Not available
Selenium Compounds	Not available

## HAZARDOUS AIR POLLUTANTS (HAPs)

Chemical or Trade Name	CAS No.
Styrene	100-42-5
Styrene oxide	96-09-3
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethylene	127-18-4
Titanium tetrachloride	7550-45-0
Toluene	108-88-3
2,4-Toluene diamine	95-80-7
2,4-Toluene diisocyanate	584-84-9
o-Toluidine	95-53-4
Toxaphene	8001-35-2
1,2,4-Trichlorobenzene	120-82-1
1,1,2-Trichloroethane	79-00-5
Trichloroethylene	79-01-6
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
Triethylamine	121-44-8
Trifluralin	1582-09-8
2,2,4-Trimethylpentane	540-84-1
Vinyl acetate	108-05-4
Vinyl bromide	593-60-2
Vinyl chloride	75-01-4
Vinylidene chloride	75-35-4
Xylenes (isomers and mixture)	1330-20-7
o-Xylene	95-47-6
m-Xylene	108-38-3
p-Xylene	106-42-3

## PRIORITY WATER POLLUTANTS (PWPs)

Chemical or Trade Name	CAS No.
Acenaphthene	83-32-9
Acenaphylene	208-96-8
Acrolein	107-02-8
Acrylonitrile	107-13-1
Aldrin	309-00-2
Anthracene	120-12-7
Antimony	7440-36-0
Arsenic	7440-38-2
Asbestos	1332-21-4
Benzene	71-43-2
Benzidine	92-87-5
Benzo(a)Anthracene	56-55-3
Benzo(a)Pyrene	50-32-8
Benzo(g,h,i)Perylene	191-24-2
3,4-Benzofluoranthene	205-99-2
Benzo(k)Fluoranthene	207-08-9
Beryllium	7440-41-7
alpha-BHC	319-84-6
beta-BHC	319-85-7
delta-BHC	319-86-8
Gamma-BHC	58-89-9
bis(-2-Chloroethoxy)Methane	111-91-1
bis(2-chloroethyl)Ether	111-44-4
bis(2-chloroisopropyl)ether	108-60-1
bis(2-Ethylhexyl)Phthalate	117-81-7
Bromoform	75-25-2
4-Bromophenyl-phenylether	101-55-3
Butylbenzylphthalate	85-68-7
Cadmium	7440-43-9
Carbon Tetrachloride	56-23-5
Chlordane	57-74-9
Chlorobenzene	108-90-7
Chlorodibromomethane	124-48-1
Chloroethane	75-00-3
2-Chloroethylvinylether	110-75-8
Chloroform	67-66-3
Chloromethane	74-87-3
2-Chloronaphthalene	91-58-7
2-Chlorophenol	95-57-8
4-Chlorophenyl-phenylether	7005-72-3
Chromium	7440-47-3
Chrysene	218-01-9
Copper	7440-50-8
Cyanide	57-12-5
4-4'-DDD	75-54-8
4-4'-DDE	72-55-9
4-4'-DDT	50-29-3

## PRIORITY WATER POLLUTANTS (PWPs)

Chemical or Trade Name	CAS No.
Dibenz(a,h)Anthracene	53-70-3
Dibutylphthalate	84-74-2
1,2-Dichlorobenzene	95-50-1
1,3-Dichlorobenzene	541-73-1
1,4-Dichlorobenzene	106-46-7
3,3-Dichlorobenzidine	91-94-1
Dichlorobromomethane	75-27-4
1,1-Dichloroethane	75-34-3
1,2-Dichloroethane	107-06-2
1,1-Dichloroethylene	75-35-4
1,2-trans-Dichloroethylene	156-60-5
2,4-Dichlorophenol	120-83-2
1,2-Dichloropropane	78-87-5
1,3-Dichloropropylene	542-75-6
Di-n-Octyl Phthalate	117-84-0
Dieldrin	60-57-1
Diethylphthalate	84-55-2
2,4-Dimethylphenol	105-67-9
4,6-Dinitro-o-cresol	534-52-1
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2,6-Dinitrotoluene	606-20-2
Dimethyl Phthalate	131-11-3
1,2-Diphenylhydrazine	122-66-7
Endosulfan I	959-98-8
Endosulfan II	33213-65-9
Endosulfan sulfanate	1031-07-8
Endrin	72-20-8
Endrin aldehyde	7421-93-4
Ethylbenzene	100-41-4
Fluoranthene	206-44-0
Fluorene	86-73-7
Heptachlor	76-44-8
Heptachlor epoxide	1024-57-3
Hexachlorobenzene	118-74-1
Hexachlorobutadiene	8-768-3
Hexachlorocyclopentadiene	77-47-4
Hexachloroethane	67-72-1
Indeno(1,2,3-cd)Pyrene	193-39-5
Isophorone	78-59-1
Lead	7439-92-1
Mercury	7439-97-6
Methyl bromide	74-83-9
Methylene Chloride	75-09-2
N-Nitroso-Di-n-propylamine	621-64-7
N-Nitrosodimethylamine	62-75-9
N-Nitrosodiphenylamine	86-30-6
Naphthalene	91-20-3
Nickel	7440-02-0

## PRIORITY WATER POLLUTANTS (PWP)

Chemical or Trade Name	CAS No.
Nitrobenzene	98-95-3
2-Nitrophenol	88-75-5
4-Nitrophenol	100-02-7
para-Chloro-meta-cresol	59-50-7
PCB-1016	12674-11-2
PCB-1221	11104-28-2
PCB-1232	11141-16-5
PCB-1242	53469-21-9
PCB-1248	12672-29-6
PCB-1254	11097-69-1
PCB-1260	11096-82-5
Pentachlorophenol	87-86-5
Phenanthrene	85-01-8
Phenol	108-95-2
Pyrene	129-00-0
Selenium	778249-2
Silver	7440-22-4
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6
1,1,2-Tetrachloroethane	79-34-5
Tetrachloroethene	127-18-4
Thallium	7440-28-0
Toluene	108-88-3
Toxaphene	8001-35-2
1,2,4-Trichlorobenzene	120-82-1
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethene	79-01-6
2,4,6-Trichlorophenol	88-06-2
Vinyl Chloride	75-01-4
Zinc	7440-66-6

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
Acetaldehyde	75-07-0
Acetic Acid	64-19-7
Acetic Anhydride	108-24-7
Acetone	67-64-1
Acetonitrile	75-05-8
2-Acetylaminofluorine	53-96-3
Acetylene tetrabromide	79-27-6
Acrolein	107-02-8
Acrylamide	79-06-1
Acrylonitrile	107-13-1
Aldrin	309-00-2
Allyl alcohol	107-18-6
Allyl chloride	107-05-1
Allyl glycidyl ether	106-92-3
Allyl propyl disulfide	2179-59-1
alpha-Alumina	1334-28-1
Aluminum, metal (as Al)	7429-90-5
4-Aminodiphenyl	92-67-1
2-Aminopyridine	504-29-0
Ammonia	7664-41-7
Ammonium sulfamate	7773-06-0
n-Amyl acetate	628-63-7
sec-Amyl acetate	626-38-0
Aniline and homologs	62-53-3
Anisidine (o-, p-isomers)	29191-52-4
Antimony and compounds (as Sb)	7440-36-0
ANTU (alpha Naphthylthiourea)	86-88-4
Arsenic, inorganic compounds (as As)	7440-38-2
Arsenic, organic compounds (as As)	7440-38-2
Arsine	7784-42-1
Asbestos	1332-21-4
Azinphos-methyl	86-50-0
Barium, soluble compounds (as Ba)	7440-39-3
Barium sulfate	7727-43-7
Benomyl	17804-35-2
Benzene	71-43-2
Benzidine	92-87-5
Benzoyl peroxide	94-36-0
Benzyl chloride	100-44-7
Beryllium and beryllium compounds (as Be)	7440-41-7
Bismuth telluride, Undoped	1304-83-1
Boron oxide	1303-86-2
Boron trifluoride	7637-07-2
Bromine	7726-95-6
Bromoform	75-25-2
Butadiene	106-99-0
2-Butanone	78-93-3
2-Butoxyethanol	111-76-2

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

Chemical or Trade Name	CAS No.
n-Butyl-acetate	123-86-4
sec-Butyl acetate	105-46-4
tert-Butyl acetate	540-88-5
n-Butyl alcohol	71-36-3
sec-Butyl alcohol	78-92-2
tert-Butyl alcohol	75-65-0
Butylamine	109-73-9
tert-Butyl chromate (as CrO <sub>2</sub> )	1189-85-1
n-Butyl glycidyl ether (BGE)	2426-08-6
Butyl mercaptan	109-79-5
p-tert-Butyltoluene	98-51-1
Cadmium (as Cd)	7440-43-9
Calcium carbonate	1317-65-3
Calcium hydroxide	1305-62-0
Calcium oxided	1305-78-8
Calcium silicate	1334-95-2
Calcium sulfate	7778-18-9
Camphor, synthetic	76-22-2
Carbaryl (Sevin)	63-25-2
Carbon black	1333-86-4
Carbon dioxide	124-38-9
Carbon disulfide	75-15-0
Carbon monoxide	630-08-0
Carbon tetrachloride	56-23-5
Cellulose	9004-34-6
Chlordane	57-74-9
Chlorinated camphene	8001-35-2
Chlorinated diphenyl oxide	55720-99-5
Chlorine	7782-50-5
Chlorine dioxide	10049-04-4
Chlorine trifluoride	7790-91-2
Chloroacetaldehyde	107-20-0
a-Chloroacetophenone	532-27-4
Chlorobenzene	108-90-7
o-Chlorobenzylidene malononitrile	2698-41-1
Chlorobromomethane	74-97-5
Chlorodiphenyl (42% Chlorine) (PCB)	53469-21-9
Chlorodiphenyl (54% Chlorine) (PCB)	11097-69-1
Chloroform	67-66-3
bis(Chloromethyl)ether	542-88-1
Chloromethyl methyl ether	107-30-2
1-Chloro-1-nitropropene	600-25-9
Chloropicrin	76-06-2
beta-Chloroprene	129-99-8
2-Chloro-6-(trichloromethyl) pyridine	1929-82-4
Chromic acid and chromates (as CrO <sub>3</sub> )	not available
Chromium compounds (as Cr)	7440-47-3
Clopidol	2971-90-6

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
Coal dust (less than 5% SiO <sub>2</sub> ), respirable fraction	not available
Coal dust (greater than or equal to 5% SiO <sub>2</sub> ), respirable fraction	
Coal tar pitch volatiles	65966-93-2
Cobalt metal, dust, and fume (as Co)	7440-48-4
Coke oven emissions	not available
Copper	7440-50-8
Cotton dust	not available
Crag herbicide	136-78-7
Cresol, all isomers	1319-77-3
Crotonaldehyde	123-73-9
Cumene	98-82-8
Cyanides (as CN)	not available
Cyclohexane	110-82-7
Cyclohexanol	108-93-0
Cyclohexanone	108-94-1
Cyclohexene	110-83-8
Cyclopentadiene	542-92-7
2,4-D (Dichlorophenoxyacetic acid)	94-75-7
Decaborane	17702-41-9
Demeton (Systox)	8065-48-3
Diacetone alcohol	123-42-2
Diazomethane	334-88-3
Diborane	19287-45-7
1,2-Dibromo-3-chloropropane	96-12-8
Dibutyl phosphate	107-66-4
Dibutyl phthalate	84-74-2
o-Dichlorobenzene	95-50-1
p-Dichlorobenzene	106-46-7
3,3'-Dichlorobenzidine	91-94-1
Dichlorodifluoromethane	75-71-8
1,3-Dichloro-5,5-dimethyl hydantoin	118-52-5
Dichlorodiphenyltrichloroethane (DDT)	50-29-3
1,1-Dichloroethane	75-34-3
1,2-Dichloroethylene	540-59-0
Dichloroethyl ether	111-44-4
Dichloromonofluoromethane	75-43-4
1,1-Dichloro-1-nitroethane	594-72-9
Dichlorotetrafluoroethane	76-14-2
Dichlorovos	62-73-7
Dichloropentadienyl iron	102-54-5
Dieldrin	60-57-1
Diethylamine	109-89-7
2-Diethylaminoethanol	100-37-8
Difluorodibromomethane	75-61-6
Diglycidyl ether (DGE)	2238-07-5
Diisobutyl ketone	108-83-8
Diisopropylamine	108-18-9
4-Dimethylaminoazobenzene	60-11-7

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
Dimethyl acetamide	127-19-5
Dimethylamine	124-40-3
Dimethylaniline	121-69-7
Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate	300-76-5
Dimethylformamide	68-12-2
1,1-Dimethylhydrazine	57-14-7
Dimethylphthalate	131-11-3
Dimethyl sulfate	77-78-1
ortho-dinitrobenzene	528-29-0
meta-dinitrobenzene	99-65-0
para-dinitrobenzene	100-25-4
Dinitro-o-cresol	534-52-1
Dinitrotoluene	25321-14-6
Dioxane	123-91-1
Diphenyl	92-52-4
Dipropylene glycol methyl ether	34590-94-8
di-sec octyl phthalate	117-81-7
Emery	12415-34-8
Endosulfan	115-29-7
Endrin	72-20-8
Epichlorohydrin	106-89-8
EPN	2104-64-5
Ethanolamine	141-43-5
2-Ethoxyethanol	110-80-5
2-Ethoxyethyl acetate	111-15-9
Ethyl acetate	141-78-6
Ethyl acrylate	140-88-5
Ethyl alcohol	64-17-5
Ethylamine	75-04-7
Ethyl amyl ketone	541-85-6
Ethyl benzene	100-41-4
Ethyl bromide	74-96-4
Ethyl butyl ketone	106-35-4
Ethyl chloride	75-00-3
Ethyl ether	60-29-7
Ethyl formate	109-94-4
Ethyl mercaptan	75-08-1
Ethyl silicate	78-10-4
Ethylene chlorohydrin	107-07-3
Ethylenediamine	107-15-3
Ethylene dibromide	106-93-4
Ethylene dichloride	107-06-2
Ethylene glycol dinitrate	628-96-6
Ethyleneimine	151-56-4
Ethylene oxide	75-21-8
N-Ethylmorpholine	100-74-3
Ferbam	14484-64-1
Ferrovandium dust	12604-58-9

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
Fluorides (as F)	not available
Fluorine	7782-41-4
Fluorotrichloromethane	75-69-4
Formaldehyde	50-00-0
Formic acid	64-18-6
Furfural	98-01-1
Furfuryl alcohol	98-00-0
Grain dust	not available
Glycerin	56-81-5
Glycidol	556-52-5
Graphite, natural, respirable dust	7782-42-5
Graphite, synthetic	not available
Gypsum	13397-24-5
Hafnium	7440-58-6
Heptachlor	76-44-8
Heptane	142-82-5
Hexachloroethane	67-72-1
Hexachloronaphthalene	1335-87-1
n-Hexane	110-54-3
2-Hexanone	591-78-6
Hexone	108-10-1
sec-Hexyl acetate	108-84-9
Hydrazine	302-01-2
Hydrogen bromide	10035-10-6
Hydrogen chloride	7647-01-0
Hydrogen cyanide	74-90-8
Hydrogen fluoride (as F)	7664-39-3
Hydrogen peroxide	7722-84-1
Hydrogen selenide (as Se)	7783-07-5
Hydrogen sulfide	7783-06-4
Hydroquinone	123-31-9
Iodine	7553-56-2
Iron oxide fume	1309-37-1
Isoamyl acetate	123-92-2
Isoamyl alcohol (primary and secondary)	123-51-3
Isobutyl acetate	110-19-0
Isobutyl alcohol	78-83-1
Isophorone	78-59-1
Isopropyl acetate	108-21-4
Isopropyl alcohol	67-63-0
Isopropylamine	75-31-0
Isopropyl ether	108-20-3
Isopropyl glycidyl ether (IGE)	4016-14-2
Kaolin	1332-58-7
Ketene	463-51-4
Lead, inorganic (as Pb)	7439-92-1
Limestone	1317-65-3
Lindane	58-89-9

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
Lithium hydride	7580-67-8
L.P.G. (Liquified petroleum gas)	68476-85-7
Magnesite	546-93-0
Magnesium oxide fume	1309-48-4
Malathion	121-75-5
Maleic anhydride	108-31-6
Manganese compounds (as Mn)	7439-96-5
Manganese fume (as Mn)	7439-96-5
Marble	1317-65-3
Mercury (aryl and inorganic) (as Hg)	7439-97-6
Mercury (organo) alkyl compounds (as Hg)	7439-97-6
Mercury (vapor) (as Hg)	7439-97-6
Mesityl oxide	141-79-7
Methoxychlor	72-43-5
2-Methoxyethanol	109-86-4
2-Methoxyethyl acetate	110-49-6
Methyl acetate	79-20-9
Methyl acetylene	74-99-7
Methyl acetylene-propadiene mixture (MAPP)	not available
Methyl acrylate	96-33-3
Methylal (Dimethoxy-methane)	109-87-5
Methyl alcohol	67-56-1
Methylamine	74-89-5
Methyl n-amyl ketone	110-43-0
Methyl bromide	74-83-9
Methyl chloride	74-87-3
Methyl chloroform	71-55-6
Methylcyclohexane	108-87-2
Methylcyclohexanol	25639-42-3
o-Methylcyclohexanone	583-60-8
Methylene chloride	75-09-2
Methyl formate	107-31-3
Methyl hydrazine	60-34-4
Methyl iodide	74-88-4
Methyl isoamy ketone	110-12-3
Methyl isobutyl carbinol	108-11-2
Methyl isocyanate	624-83-9
Methyl mercaptan	74-93-1
Methyl methacrylate	80-62-6
alpha-Methyl styrene	95-83-9
Methylene bisphenyl isocyanate (MDI)	101-68-8
Methylenedianiline	101-77-9
Molybdenum	7439-98-7
Monomethyl aniline	100-61-8
Morpholine	110-91-8
Naphtha (Coal tar)	8030-30-6
Naphtalene	91-20-3
alpha-Naphthylamine	134-32-7

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
beta-Naphthylamine	91-59-8
Nickel carbonyl (as Ni)	13463-39-3
Nickel, metal and insoluble compounds (as Ni)	13463-39-3
Nickel, soluble compounds (as Ni)	13463-39-3
Nicotine	54-11-5
Nitric acid	7697-37-2
Nitric oxide	10102-43-9
p-Nitroaniline	100-01-6
Nitrobenzene	98-95-3
p-Nitrochlorobenzene	100-00-5
4-Nitrodiphenyl	92-93-3
Nitroethane	79-24-3
Nitrogen dioxide	10102-44-0
Nitrogen trifluoride	7783-54-2
Nitoglycerin	55-63-0
Nitromethane	75-52-5
1-Nitropropane	108-03-2
2-Nitropropane	79-46-9
N-Nitrosodimethylamine	not available
o-Nitrosodimethylamine	88-72-2
m-Nitrosodimethylamine	99-08-1
p-Nitrosodimethylamine	99-99-0
Octachloronaphthalene	2234-13-1
Octane	1111-65-9
Oil mist, mineral	8012-95-1
Osmium tetroxide (as Os)	20816-12-0
Oxalic acid	144-62-7
Oxygen difluoride	7783-41-7
Ozone	10028-15-6
Paraquat, respirable dust	4685-14-7
Parathion	56-38-2
Particulates not otherwise regulated (PNOR)	not available
Pentaborane	19624-22-7
Pentachloronaphthalene	1321-64-8
Pentachlorophenol	87-86-5
Pentaerythritol	115-77-5
Pentane	109-66-0
2-Pentanone	107-87-9
Perechloroethylene	127-18-4
Perchloromethyl mercaptan	594-42-3
Perchloryl fluoride	7616-94-6
Perlite	93763-70-3
Petroleum distillates	8002-05-9
Phenol	108-95-2
p-Phenylene diamine	106-50-3
Phenyl ether, vapor	101-84-8
Phenyl ether-biphenyl mixture, vapor	not available
Phenyl glycidyl ether (PGE)	122-60-1

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
Phenylthydrazine	100-63-0
Phosdrin	7786-34-7
Phosgene	75-44-5
Phosphine	7803-51-2
Phosphoric acid	7664-38-2
Phosphorus (yellow)	7723-14-0
Phosphorus pentachloride	10026-13-8
Phosphorus pentasulfide	1314-80-3
Phosphorus trichloride	7719-12-2
Phthalic anhydride	85-44-9
Picioram	1918-02-1
Picric acid	88-89-1
Pindone	83-26-1
Plaster of Parts	26499-65-0
Platinum (as Pt)	7440-06-4
Portland cement	65997-15-1
Propane	74-98-6
beta-Propiolactone	57-57-8
n-Propyl acetate	109-60-4
n-Propyl alcohol	71-23-8
n-Propyl nitrate	627-13-4
Propylene dichloride	78-87-5
Propylene imine	75-55-8
Propylene oxide	75-56-9
Pyrethrum	8003-34-7
Pyridine	110-86-1
Quinone	106-51-4
Rhodium (as Rh), metal, fume, and insoluble compounds	7440-16-6
Rhodium (as Rh), soluble compounds	7440-16-6
Ronnel	299-84-3
Rotenone	83-79-4
Rouge	not available
Selenium compounds (as Se)	7782-49-2
Selenium hexafluoride (as Se)	7783-79-1
Silica, amorphous, precipitated and gel	112926-00-8
Silica, amorphous, diatomaceous earth, containing less than 1% crystalline silica	61790-53-2
Silica, crystalline cristobalite, respirable dust	14464-46-1
Silica, crystalline quartz, respirable dust	14808-60-7
Silica, crystalline tripoli (as quartz), respirable dust	1317-95-9
Silica, crystalline tridymite, respirable dust	15468-32-3
Silica, fused, respirable dust	60676-86-0
Mica (respirable dust)	12001-26-2
Soapstone, total dust	not available
Soapstone, respirable dust	not available
Talc (containing asbestos)	not available
Talc (containing no asbestos), respirable dust	14807-96-6
Tremolite, asbestiform	not available

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
Silicon	7440-21-3
Silicon carbide	409-21-2
Silver, metal and soluble compounds (as Ag)	7440-22-4
Sodium fluoracetate	62-74-8
Sodium hydroxide	1310-73-2
Starch	9005-25-8
Stibine	7803-52-3
Stoddard solvent *	8052-41-3
Strychnine	57-24-9
Styrene	100-42-5
Sucrose	57-50-1
Sulfur dioxide	7446-09-5
Sulfur hexafluoride	2551-62-4
sulfuric acid	7664-93-9
Sulfur monochloride	10025-67-9
Sulfur pentafluoride	5714-22-7
Sulfuryl fluoride	2699-79-8
2,4,5-T (2,4,5-Tetrachlorophenoxyacetic acid)	93-76-5
Tantalum, metal and oxide dust	7440-25-7
TEDP	3689-24-5
Tellurium and compounds (as Te)	13494-80-9
Tellurium hexafluoride (as Te)	7783-80-4
Temephos	3383-96-8
TEPP	107-49-3
Terphenyls	26140-60-3
1,1,1,2-Tetrachloro-2,2-difluoroethane	76-11-9
1,1,2,2-Tetrachloro-2,2-difluoroethane	76-12-0
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloronaphthalene	1335-88-2
Tetraethyl lead (as Pb)	78-00-2
Tetrahydrofuran	109-99-9
Tetramethyl lead (as Pb)	75-74-1
Tetramethyl succinonitrile	3333-52-6
Tetranitromethane	509-14-8
Tetryl	479-45-8
Thallium, soluble compounds (as Tl)	7440-28-0
4,4'-Thiobis	96-69-5
Thiram	137-26-8
Tin, inorganic compounds (except oxides) (as Sn)	7440-31-5
Tin, organic compounds (as Sn)	7440-31-5
Titanium oxide	13463-67-7
Toluene	108-88-3
Toluene-2,4-diisocyanate	584-84-9
o-Toluidine	95-53-4
Tributyl phosphate	126-73-8
1,1,2-Trichloroethane	79-00-5
Trichloroethylene	79-01-5
Trichloronaphthalene	1321-65-9

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION CHEMICALS  
(OSHA)**

<b>Chemical or Trade Name</b>	<b>CAS No.</b>
1,2,3-Trichloropropane	96-18-4
1,1,2-Trichloro-1,2,2-trifluoroethane	121-44-8
Triethylamine	121-44-8
Trifluorobromomethane	75-63-8
2,4,6-trinitrotoluene	118-96-7
Triorthocresyl phosphate	78-30-8
Triphenyl phosphate	115-86-6
Turpentine	8006-64-2
Uranium (as U)	7440-61-1
Vanadium	1314-62-1
Vegetable oil mist	not available
Vinyl chloride	75-01-4
Vinyl toluene	25013-15-4
Warfarin	81-81-2
Xylenes (o-,m-,p-isomers)	1330-20-7
Xylidine	1300-73-8
Yttrium	7440-65-5
Zinc chloride fume	7646-85-7
Zinc oxide fume	1314-13-2
Zinc oxide	1314-13-2
Zinc stearate	557-05-1
Zirconium compounds	7440-67-7

## APPENDIX B

### CAS Number Cross-Reference List

This Appendix contains the regulated chemical names in numerical order relative to their assigned CAS number.

#### HAZARDOUS AIR POLLUTANTS (HAPs)

CAS No.	Chemical or Trade Name
50-00-0	Formaldehyde
51-28-5	2,4-Dinitrophenol
51-79-6	Ethyl carbamate
53-96-3	2-Acetylaminofluorene
56-23-5	Carbon tetrachloride
56-38-2	Parathion
57-14-7	1,1-Dimethyl hydrazine
57-57-8	beta-Propiolactone
57-74-9	Chlordane
58-89-9	Lindane (all isomers)
59-89-2	N-Nitrosomorpholine
60-11-7	Dimethyl aminoazobenzene
60-34-4	Methyl hydrazine
60-35-5	Acetamide
62-53-3	Aniline
62-73-7	Dichlorvos
62-75-9	N-Nitrosodimethylamine
63-25-2	Carbaryl
64-67-5	Diethyl sulfate
67-56-1	Methanol
67-66-3	Chloroform
67-72-1	Hexachloroethane
68-12-2	Dimethyl formamide
71-43-2	Benzene (including benzene from gasoline)
71-55-6	Methyl chloroform
72-43-5	Methoxychlor
72-55-9	DDE
74-83-9	Methyl bromide
74-87-3	Methyl chloride
74-88-4	Methyl iodide
75-00-3	Ethyl chloride
75-01-4	Vinyl chloride
75-05-8	Acetonitrile
75-07-0	Acetaldehyde
75-09-2	Methylene chloride
75-15-0	Carbon disulfide
75-21-8	Ethylene oxide
75-25-2	Bromoform

## HAZARDOUS AIR POLLUTANTS (HAPs)

CAS No.	Chemical or Trade Name
75-34-3	Ethylidene dichloride
75-35-4	Vinylidene chloride
75-44-5	Phosgene
75-55-8	1,2-Propylenimine
75-56-9	Propylene oxide
76-44-8	Heptachlor
77-47-4	Hexachlorocyclopentadiene
77-78-1	Dimethyl sulfate
78-59-1	Isophorone
78-87-5	Propylene dichloride
78-93-3	Methyl ethyl ketone
79-00-5	1,1,2-Trichloroethane
79-01-6	Trichloroethylene
79-06-1	Acrylamide
79-10-7	Acrylic acid
79-11-8	Chloroacetic acid
79-34-5	1,1,2,2-Tetrachloroethane
79-44-7	Dimethyl carbamoyl chloride
79-46-9	2-Nitropropane
80-62-6	Methyl methacrylate
82-68-8	Pentachloronitrobenzene
84-74-2	Dibutylphthalate
85-44-9	Phthalic anhydride
87-68-3	Hexachlorobutadiene
87-86-5	Pentachlorophenol
88-06-2	2,4,6-Trichlorophenol
90-04-0	o-Anisidine
91-20-3	Naphthalene
91-22-5	Quinoline
91-94-1	3,3'Dichlorobenzidine
92-52-4	Biphenyl
92-67-1	4-Aminobiphenyl
92-87-5	Benzidine
92-93-3	4-Nitrobiphenyl
94-75-7	2,4-D, Salts and Esters
95-47-6	o-Xylene
95-48-7	o-Cresol
95-53-4	o-Toluidine
95-80-7	2,4-Toluene diamine
95-95-4	2,4,5-Trichlorophenol
96-09-3	Styrene oxide
96-12-8	1,2-Dibromo-3-chloropropane
96-45-7	Ethylene thiourea
98-07-7	Benzotrichloride
98-82-8	Cumene
98-86-2	Acetophenone

## HAZARDOUS AIR POLLUTANTS (HAPs)

CAS No.	Chemical or Trade Name
98-95-3	Nitrobenzene
100-02-7	4-Nitrophenol
100-41-4	Ethyl benzene
100-42-5	Styrene
100-44-7	Benzyl chloride
101-14-4	4,4'Methylene bis(2-chloroaniline)
101-68-8	Methylene diphenyl diisocyanate
101-77-9	4,4'-Methylenedianiline
106-42-3	p-Xylene
106-44-5	p-Cresol
106-46-7	1,4-Dichlorobenzene
106-50-3	p-Phenylenediamine
106-51-4	Quinone
106-88-7	1,2-Epoxybutane
106-89-8	Epichlorohydrin
106-93-4	Ethylene dibromide
106-99-0	1,3-Butadiene
107-02-8	Acrolein
107-05-1	Allyl chloride
107-06-2	Ethylene dichloride
107-13-1	Acrylonitrile
107-21-1	Ethylene glycol
107-30-2	Chloromethyl methyl ether
108-05-4	Vinyl acetate
108-10-1	Methyl isobutyl ketone
108-31-6	Maleic anhydride
108-38-3	m-Xylene
108-39-4	m-Cresol
108-88-3	Toluene
108-90-7	Chlorobenzene
108-95-2	Phenol
110-54-3	Hexane
111-42-2	Diethanolamine
111-44-4	Dichloroethyl ether
114-26-1	Propoxur
117-81-7	Bis(2-ethylhexyl)phthalate (DEHP)
118-74-1	Hexachlorobenzene
119-90-4	3,3'-Dimethoxybenzidine
119-93-7	3,3'-Dimethyl benzidine
120-80-9	Catechol
120-82-1	1,2,4-Trichlorobenzene
121-14-2	2,4-Dinitrotoluene
121-44-8	Triethylamine
121-69-7	N,N-Dimethylaniline
122-66-7	1,2-Diphenylhydrazine
123-31-9	Hydroquinone

## HAZARDOUS AIR POLLUTANTS (HAPs)

CAS No.	Chemical or Trade Name
123-38-6	Propionaldehyde
123-91-1	1,4-Dioxane
126-99-8	Chloroprene
127-18-4	Tetrachloroethylene
131-11-3	Dimethyl phthalate
132-64-9	Dibenzofurans
133-06-2	Captan
133-90-4	Chloramben
140-88-5	Ethyl acrylate
151-56-4	Ethylene imine
156-62-7	Calcium cyanamide
302-01-2	Hydrazine
334-88-3	Diazomethane
463-58-1	Carbonyl sulfide
510-15-6	Chlorobenzilate
532-27-4	2-Chloroacetophenone
534-52-1	4,6-Dinitro- <i>o</i> -cresol, and salts
540-84-1	2,2,4-Trimethylpentane
542-75-6	1,3-Dichloropropene
542-88-1	Bis(chloromethyl)ether
584-84-9	2,4-Toluene diisocyanate
593-60-2	Vinyl bromide
624-83-9	Methyl isocyanate
680-31-9	Hexamethylphosphoramide
684-93-5	N-Nitroso-N-methylurea
822-06-0	Hexamethylene-1,6-diisocyanate
1120-71-4	1,3-Propane sultone
1319-77-3	Cresols/Cresylic acid (isomers and mixture)
1330-20-7	Xylenes (isomers and mixture)
1332-21-4	Asbestos
1336-36-3	Polychlorinated biphenyls (PCB's)
1582-09-8	Trifluralin
1634-04-4	Methyl tert-butyl ether
1746-01-6	2,3,7,8-Tetrachlorodibenzo- <i>p</i> -dioxin
7550-45-0	Titanium tetrachloride
7647-01-0	Hydrochloric acid
7664-39-3	Hydrogen fluoride
7723-14-0	Phosphorus
7782-50-5	Chlorine
7803-51-2	Phosphine
8001-35-2	Toxaphene
Not available	Antimony Compounds
Not available	Arsenic Compounds (inorganic including arsine)
Not available	Beryllium Compounds
Not available	Cadmium Compounds
Not available	Chromium Compounds

**HAZARDOUS AIR POLLUTANTS (HAPs)**

<b>CAS No.</b>	<b>Chemical or Trade Name</b>
Not available	Cobalt Compounds
Not available	Coke Oven Emissions
Not available	Cyanide Compounds
Not available	Fine mineral fibers
Not available	Glycol ethers
Not available	Lead Compounds
Not available	Manganese Compounds
Not available	Mercury Compounds
Not available	Nickel Compounds
Not available	Polycyclic Organic Matter
Not available	Radionuclides (including radon)
Not available	Selenium Compounds

## PRIORITY WATER POLLUTANTS (PWPs)

CAS No.	Chemical or Trade Name
50-29-3	4-4'-DDT
50-32-8	Benzo(a)Pyrene
51-28-5	2,4-Dinitrophenol
53-70-3	Dibenz(a,h)Anthracene
56-23-5	Carbon Tetrachloride
56-55-3	Benzo(a)Anthracene
57-12-5	Cyanide
57-74-9	Chlordane
58-89-9	Gamma-BHC
59-50-7	para-Chloro-meta-cresol
60-57-1	Dieldrin
62-75-9	N-Nitrosodimethylamine
67-66-3	Chloroform
67-72-1	Hexachloroethane
71-43-2	Benzene
71-55-6	1,1,1-Trichloroethane
72-20-8	Endrin
72-55-9	4-4'-DDE
74-83-9	Methyl bromide
74-87-3	Chloromethane
75-00-3	Chloroethane
75-01-4	Vinyl Chloride
75-09-2	Methylene Chloride
75-25-2	Bromoform
75-27-4	Dichlorobromomethane
75-34-3	1,1-Dichloroethane
75-35-4	1,1-Dichloroethylene
75-54-8	4-4'-DDD
76-44-8	Heptachlor
77-47-4	Hexachlorocyclopentadiene
78-59-1	Isophorone
78-87-5	1,2-Dichloropropane
79-00-5	1,1,2-trichloroethane
79-01-6	Trichloroethene
79-345	1,1,2,2-Tetrachloroethane
83-32-9	Acenaphthene
84-55-2	Diethylphthalate
84-74-2	Dibutylphthalate
85-01-8	Phenanthrene
85-30-6	N-Nitrosodiphenylamine
85-68-7	Butylbenzylphthalate
86-73-7	Fluorene
87-68-3	Hexachlorobutadiene
87-86-5	Pentachlorophenol
88-062	2,4,6-Trichlorophenol

## PRIORITY WATER POLLUTANTS (PWP's)

CAS No.	Chemical or Trade Name
88-75-5	2-Nitrophenol
91-20-3	Naphthalene
91-58-7	2-Chloronaphthalene
91-94-1	3,3-Dichlorobenzidene
92-87-5	Benzidine
95-50-1	1,2-Dichlorobenzene
95-57-8	2-Chlorophenol
98-95-3	Nitrobenzene
100-02-7	4-Nitrophenol
100-41-4	Ethylbenzene
101-55-3	4-Bromophenyl-phenylether
105-67-9	2,4-Dimethylphenol
106-46-7	1,4-Dichlorobenzene
107-02-8	Acrolein
107-06-2	1,2-Dichloroethane
107-13-1	Acrylonitrile
108-60-1	bis(2-chloroisopropyl)ether
108-88-3	Toluene
108-90-7	Chlorobenzene
108-95-2	Phenol
110-75-8	2-Chloroethylvinylether
111-44-4	bis(2-chloroethyl)Ether
111-91-1	bis(-2-Chloroethoxy)Methane
117-81-7	bis(2-Ethylhexyl)Phthalate
117-84-0	Di-n-Octyl Phthalate
118-74-1	Hexachlorobenzene
120-12-7	Anthracene
120-82-1	1,2,4-Trichlorobenzene
120-83-2	2,4-Dichlorophenol
121-14-2	2,4-Dinitrotoluene
122-66-7	1,2-Diphenylhydrazine
124-48-1	Chlorodibromomethane
127-18-4	Tetrachloroethene
129-00-0	Pyrene
131-11-3	Dimethyl Phthalate
156-60-5	1,2-trans-Dichloroethylene
191-24-2	Benzo(g,h,l)Perylene
193-39-5	Indeno(1,2,3-cd)Pyrene
205-99-2	3,4-Benzofluoranthene
206-44-0	Fluoranthene
207-08-9	Benzo(k)Fluoranthene
208-96-8	Acenaphylene
218-01-9	Chrysene
309-00-2	Aldrin
319-84-6	alpha-BHC
319-85-7	beta-BHC

## PRIORITY WATER POLLUTANTS (PWPs)

CAS No.	Chemical or Trade Name
319-86-8	delta-BHC
534-52-1	4,6-Dinitro-o-cresol
541-73-1	1,3-Dichlorobenzene
542-75-6	1,3-Dichloropropylene
606-20-2	2,6-Dinitrotoluene
621-64-7	N-Nitroso-Di-n-propylamine
959-98-8	Endosulfan I
1024-57-3	Heptachlor epoxide
1031-07-8	Endosulfan sulfanate
1332-21-4	Asbestos
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin
7005-72-3	4-Chlorophenyl-phenylether
7421-93-4	Endrin aldehyde
7439-92-1	Lead
7439-97-6	Mercury
7440-02-0	Nickel
7440-22-4	Silver
7440-28-0	Thallium
7440-36-0	Antimony
7440-38-2	Arsenic
7440-41-7	Beryllium
7440-43-9	Cadmium
7440-47-3	Chromium
7440-50-8	Copper
7440-66-6	Zinc
7782-49-2	Selenium
8001-35-2	Toxaphene
11096-82-5	PCB-1260
11097-69-1	PCB-1254
11104-28-2	PCB-1221
11141-16-5	PCB-1232
12672-29-6	PCB-1248
12674-11-2	PCB-1016
33213-65-9	Endosulfan II
53469-21-9	PCB-1242

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

<b>CAS No.</b>	<b>Chemical or Trade Name</b>
50-00-0	Formaldehyde
50-29-3	Dichlorodiphenyltrichloroethane (DDT)
53-96-3	2-Acetylaminofluorine
54-11-5	Nicotine
55-63-0	Nitoglycerin
56-23-5	Carbon tetrachloride
56-38-2	Parathion
56-81-5	Glycerin
57-14-7	1,1-Dimethylhydrazine
57-24-9	Strychnine
57-50-1	Sucrose
57-57-8	beta-Propiolactone
57-74-9	Chlordane
58-89-9	Lindane
60-11-7	4-Dimethylaminoazobenzene
60-29-7	Ethyl ether
60-34-4	Methyl hydrazine
60-57-1	Dieldrin
62-53-3	Aniline and homologs
62-73-7	Dichlorovos
62-74-8	Sodium fluoracetate
63-25-2	Carbaryl (Sevin)
64-17-5	Ethyl alcohol
64-18-6	Formic acid
64-19-7	Acetic Acid
67-56-1	Methyl alcohol
67-63-0	Isopropyl alcohol
67-64-1	Acetone
67-66-3	Chloroform
67-72-1	Hexachloroethane
68-12-2	Dimethylformamide
71-23-8	n-Propyl alcohol
71-36-3	n-Butyl alcohol
71-43-2	Benzene
71-55-6	Methyl chloroform
72-20-8	Endrin
72-43-5	Methoxychlor
74-83-9	Methyl bromide
74-87-3	Methyl chloride
74-88-4	Methyl iodide
74-89-5	Methylamine
74-90-8	Hydrogen cyanide
74-93-1	Methyl mercaptan
74-96-4	Ethyl bromide
74-97-5	Chlorobromomethane

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

CAS No.	Chemical or Trade Name
74-98-6	Propane
74-99-7	Methyl acetylene
75-00-3	Ethyl chloride
75-01-4	Vinyl chloride
75-04-7	Ethylamine
75-05-8	Acetonitrile
75-07-0	Acetaldehyde
75-08-1	Ethyl mercaptan
75-09-2	Methylene chloride
75-15-0	Carbon disulfide
75-21-8	Ethylene oxide
75-25-2	Bromoform
75-31-0	Isopropylamine
75-343	1,1-Dichloroethane
75-43-4	Dichloromonofluoromethane
75-44-5	Phosgene
75-52-5	Nitromethane
75-55-8	Propylene imine
75-56-9	Propylene oxide
75-616	Difluorodibromomethane
75-63-8	Trifluorobromomethane
75-65-0	tert-Butyl alcohol
75-69-4	Fluorotrichloromethane
75-71-8	Dichlorodifluoromethane
75-74-1	Tetramethyl lead (as Pb)
76-06-2	Chloropicrin
76-11-9	1,1,1,2-Tetrachloro-2,2-difluoroethane
76-12-0	1,1,2,2-Tetrachloro-2,2-difluoroethane
76-14-2	Dichlorotetrafluoroethane
76-22-2	Camphor, synthetic
76-44-8	Heptachlor
77-78-1	Dimethyl sulfate
78-00-2	Tetraethyl lead (as Pb)
78-10-4	Ethyl silicate
78-30-8	Triorthocresyl phosphate
78-59-1	Isophorone
78-83-1	Isobutyl alcohol
78-87-5	Propylene dichloride
78-92-2	sec-Butyl alcohol
78-93-3	2-Butanone
79-00-5	1,1,2-Trichloroethane
79-01-5	Trichloroethylene
79-06-1	Acrylamide
79-20-9	Methyl acetate
79-24-3	Nitroethane

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

<b>CAS No.</b>	<b>Chemical or Trade Name</b>
79-27-6	Acetylene tetrabromide
79-34-5	1,1,2,2-Tetrachloroethane
79-46-9	2-Nitropropane
80-62-6	Methyl methacrylate
81-81-2	Warfarin
83-26-1	Pindone
83-79-4	Rotenone
84-74-2	Dibutyl phthalate
85-44-9	Phthalic anhydride
86-50-0	Azinphos-methyl
86-88-4	ANTU (alpha Naphththiourea)
87-86-5	Pentachlorophenol
88-72-2	o-Nitrosodimethylamine
88-89-1	Picric acid
91-20-3	Naphtalene
91-59-8	beta-Naphthylamine
91-94-1	3,3'-Dichlorobenzidine
92-52-4	Diphenyl
92-67-1	4-Aminodiphenyl
92-87-5	Benzidine
92-93-3	4-Nitrodiphenyl
93-76-5	2,4,5-T (2,4,5-Tetrachlorophenoxyacetic acid)
94-36-0	Benzoyl peroxide
94-75-7	2,4-D (Dichlorophenoxyacetic acid)
95-50-1	o-Dichlorobenzene
95-53-4	o-Toluidine
95-83-9	alpha-Methyl styrene
96-12-8	1,2-Dibromo-3-chloropropane
96-18-4	1,2,3-Trichloropropane
96-33-3	Methyl acrylate
96-69-5	4,4'-Thiobis
98-00-0	Furfuryl alcohol
98-01-1	Furfural
98-51-1	p-tert-Butyltoluene
98-82-8	Cumene
98-95-3	Nitrobenzene
99-08-1	m-Nitrosodimethylamine
99-65-0	meta-dinitrobenzene
99-99-0	p-Nitrosodimethylamine
100-00-5	p-Nitrochlorobenzene
100-01-6	p-Nitroaniline
100-25-4	para-dinitrobenzene
100-37-8	2-Diethylaminoethanol
100-41-4	Ethyl benzene
100-42-5	Styrene

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

<b>CAS No.</b>	<b>Chemical or Trade Name</b>
100-44-7	Benzyl chloride
100-61-8	Monomethyl aniline
100-63-0	Phenylhydrazine
100-74-3	N-Ethylmorpholine
101-68-8	Methylene bisphenyl isocyanate (MDI)
101-77-9	Methylenedianiline
101-84-8	Phenyl ether, vapor
102-54-5	Dichloropentadienyl iron
105-46-4	sec-Butyl acetate
106-354	Ethyl butyl ketone
106-46-7	p-Dichlorobenzene
106-50-3	p-Phenylene diamine
106-51-4	Quinone
106-89-8	Epichlorohydrin
106-92-3	Allyl glycidyl ether
106-93-4	Ethylene dibromide
106-99-0	Butadiene
107-02-8	Acrolein
107-05-1	Allyl chloride
107-06-2	Ethylene dichloride
107-07-3	Ethylene chlorohydrin
107-13-1	Acrylonitrile
107-15-3	Ethylenediamine
107-18-6	Allyl alcohol
107-20-0	Chloroacetaldehyde
107-30-2	Chloromethyl methyl ether
107-31-3	Methyl formate
107-49-3	TEPP
107-66-4	Dibutyl phosphate
107-87-9	2-Pentanone
108-03-2	1-Nitropropane
108-10-1	Hexone
108-11-2	Methyl isobutyl carbinol
108-18-9	Diisopropylamine
108-20-3	Isopropyl ether
108-21-4	Isopropyl acetate
108-24-7	Acetic Anhydride
108-31-6	Maleic anhydride
108-83-8	Diisobutyl ketone
108-84-9	sec-Hexyl acetate
108-87-2	Methylcyclohexane
108-883	Toluene
108-90-7	Chlorobenzene
108-93-0	Cyclohexanol
108-94-1	Cyclohexanone

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

CAS No.	Chemical or Trade Name
108-95-2	Phenol
109-60-4	n-Propyl acetate
109-66-0	Pentane
109-73-9	Butylamine
109-79-5	Butyl mercaptan
109-86-4	2-Methoxyethanol
109-87-5	Methyial (Dimethoxy-methane)
109-89-7	Diethylamine
109-94-4	Ethyl formate
109-99-9	Tetrahydrofuran
110-12-3	Methyl isoamy ketone
110-19-0	Isobutyl acetate
110-43-0	Methyl n-amyl ketone
110-49-6	2-Methoxyethyl acetate
110-54-3	n-Hexane
110-80-5	2-Ethoxyethanol
110-82-7	Cyclohexane
110-83-8	Cyclohexene
110-86-1	Pyridine
110-91-8	Morpholine
111-15-9	2-Ethoxyethyl acetate
111-44-4	Dichloroethyl ether
111-76-2	2-Butoxyethanol
115-29-7	Endosulfan
115-77-5	Pentaerythritol
115-86-6	Triphenyl phosphate
117-81-7	di-sec octyl phthalate
118-52-5	1,3-Dichloro-5,5-dimethyl hydantoin
118-96-7	2,4,6 trinitrotoluene
121-44-8	1,1,2-Trichloro-1,2,2-trifluoroethane
121-44-8	Triethylamine
121-69-7	Dimethylaniline
121-75-5	Malathion
122-60-1	Phenyl glycidyl ether (PGE)
123-31-9	Hydroquinone
123-42-2	Diacetone alcohol
123-51-3	Isoamyl alcohol (primary and secondary)
123-73-9	Crotonaldehyde
123-86-4	n-Butyl-acetate
123-91-1	Dioxane
123-922	Isoamyl acetate
124-38-9	Carbon dioxide
124-40-3	Dimethylamine
126-73-8	Tributyl phosphate
127-18-4	Perechloroethylene

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

CAS No.	Chemical or Trade Name
127-19-5	Dimethyl acetamide
129-99-8	beta-Chloroprene
131-11-3	Dimethylphthalate
134-32-7	alpha-Naphthylamine
136-78-7	Crag herbicide
137-26-8	Thiram
140-88-5	Ethyl acrylate
141-43-5	Ethanolamine
141-78-6	Ethyl acetate
141-79-7	Mesityl oxide
142-82-5	Heptane
144-62-7	Oxalic acid
151-56-4	Ethyleneimine
299-84-3	Ronnel
300-76-5	Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate
302-01-2	Hydrazine
309-00-2	Aldrin
334-88-3	Diazomethane
409-21-2	Silicon carbide
463-51-4	Ketene
479-458	Tetryl
504-29-0	2-Aminopyridine
509-14-8	Tetranitromethane
528-29-0	ortho-dinitrobenzene
532-27-4	a-Chloroacetophenone
534-52-1	Dinitro-o-cresol
540-59-0	1,2-Dichloroethylene
540-88-5	tert-Butyl acetate
541-85-6	Ethyl amyl ketone
542-88-1	bis(Chloromethyl)ether
542-92-7	Cyclopentadiene
546-93-0	Magnesite
556-52-5	Glycidol
557-05-1	Zinc stearate
583-60-8	o-Methylcyclohexanone
584-84-9	Toluene-2,4-diisocyanate
591-786	2-Hexanone
594-42-3	Perchloromethyl mercaptan
594-72-9	1,1-Dichloro-1-nitroethane
600-25-9	1-Chloro-1-nitropropene
624-83-9	Methyl isocyanate
626-38-0	sec-Amyl acetate
627-13-4	n-Propyl nitrate
628-63-7	n-Amyl acetate
628-96-6	Ethylene glycol dinitrate

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

<b>CAS No.</b>	<b>Chemical or Trade Name</b>
630-08-0	Carbon monoxide
1111-65-9	Octane
1189-85-1	tert-Butyl chromate (as CrO <sub>2</sub> )
1300-73-8	Xylidine
1303-86-2	Boron oxide
1304-83-1	Bismuth telluride, Undoped
1305-62-0	Calcium hydroxide
1305-78-8	Calcium oxided
1309-37-1	Iron oxide fume
1309-48-4	Magnesium oxide fume
1310-73-2	Sodium hydroxide
1314-13-2	Zinc oxide
1314-13-2	Zinc oxide fume
1314-62-1	Vanadium
1314-80-3	Phosphorus pentasulfide
1317-65-3	Calcium carbonate
1317-65-3	Limestone
1317-65-3	Marble
1317-95-9	Silica, crystalline tripoli (as quartz), respirable dust
1319-77-3	Cresol, all isomers
1321-64-8	Pentachloronaphthalene
1321-65-9	Trichloronaphthalene
1330-20-7	Xylenes (o-,m-,p-isomers)
1332-21-4	Asbestos
1332-58-7	Kaolin
1333-86-4	Carbon black
1334-28-1	alpha-Alumina
1334-95-2	Calcium silicate
1335-87-1	Hexachloronaphthalene
1335-88-2	Tetrachloronaphthalene
1918-02-1	Picioram
1929-82-4	2-Chloro-6-(trichloromethyl) pyridine
2104-64-5	EPN
2179-591	Allyl propyl disulfide
2234-131	Octachloronaphthalene
2238-07-5	Diglycidyl ether (DGE)
2426-08-6	n-Butyl glycidyl ether (BGE)
2551-62-4	Sulfur hexafluoride
2698-41-1	o-Chlorobenzylidene malononitrile
2699-79-8	Sulfuryl fluoride
2971-90-6	Clopidol
3333-52-6	Tetramethyl succinonitrile
3383-96-8	Temephos
3689-24-5	TEDP
4016-14-2	Isopropyl glycidyl ether (IGE)

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

CAS No.	Chemical or Trade Name
4685-14-7	Paraquat, respirable dust
5714-22-7	Sulfur pentafluoride
7429-90-5	Aluminum, metal (as Al)
7439-92-1	Lead, inorganic (as Pb)
7439-96-5	Manganese compounds (as Mn)
7439-96-5	Manganese fume (as Mn)
7439-97-6	Mercury (aryl and inorganic) (as Hg)
7439-97-6	Mercury (organo) alkyl compounds (as Hg)
7439-97-6	Mercury (vapor) (as Hg)
7439-98-7	Molybdenum
7440-06-4	Platinum (as Pt)
7440-16-6	Rhodium (as Rh), metal, fume, and insoluble compounds
7440-16-6	Rhodium (as Rh), soluble compounds
7440-213	Silicon
7440-22-4	Silver, metal and soluble compounds (as Ag)
7440-25-7	Tantalum, metal and oxide dust
7440-28-0	Thallium, soluble compounds (as Tl)
7440-31-5	Tin, inorganic compounds (except oxides) (as Sn)
7440-31-5	Tin, organic compounds (as Sn)
7440-36-0	Antimony and compounds (as Sb)
7440-38-2	Arsenic, inorganic compounds (as As)
7440-38-2	Arsenic, organic compounds (as As)
7440-39-3	Barium, soluble compounds (as Ba)
7440-41-7	Beryllium and beryllium compounds (as Be)
7440-43-9	Cadmium (as Cd)
7440-47-3	Chromium compounds (as Cr)
7440-48-4	Cobalt metal, dust, and fume (as Co)
7440-50-8	Copper
7440-58-6	Hafnium
7440-61-1	Uranium (as U)
7440-65-5	Yttrium
7440-67-7	Zirconium compounds
7446-09-5	Sulfur dioxide
7553-56-2	Iodine
7580-67-8	Lithium hydride
7616-94-6	Perchloryl fluoride
7646-85-7	Zinc chloride fume
7637-07-2	Boron trifluoride
7647-01-0	Hydrogen chloride
7664-38-2	Phosphoric acid
7664-39-3	Hydrogen fluoride (as F)
7664-41-7	Ammonia
7664-93-9	sulfuric acid
7697-37-2	Nitric acid

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

CAS No.	Chemical or Trade Name
7719-12-2	Phosphorus trichloride
7722-84-1	Hydrogen peroxide
7723-14-0	Phosphorus (yellow)
7726-95-6	Bromine
7727-43-7	Barium sulfate
7773-06-0	Ammonium sulfamate
7778-18-9	Calcium sulfate
7782-41-4	Fluorine
7782-42-5	Graphite, natural, respirable dust
7782-49-2	Selenium compounds (as Se)
7782-50-5	Chlorine
7783-06-4	Hydrogen sulfide
7783-07-5	Hydrogen selenide (as Se)
7783-41-7	Oxygen difluoride
7783-54-2	Nitrogen trifluoride
7783-79-1	Selenium hexafluoride (as Se)
7783-80-4	Tellurium hexafluoride (as Te)
7784-42-1	Arsine
7786-34-7	Phosdrin
7790-91-2	Chlorine trifluoride
7803-51-2	Phosphine
7803-52-3	Stibine
8001-35-2	Chlorinated camphene
8002-05-9	Petroleum distillates
8003-34-7	Pyrethrum
8006-64-2	Turpentine
8012-95-1	Oil mist, mineral
8030-30-6	Naphtha (Coal tar)
8052-41-3	Stoddard solvent
8065-48-3	Demeton (Systox)
9004-34-6	Cellulose
9005-25-8	Starch
10025-67-9	Sulfur monochloride
10026-13-8	Phosphorus pentachloride
10028-15-6	Ozone
10035-10-6	Hydrogen bromide
10049-04-4	Chlorine dioxide
10102-43-9	Nitric oxide
10102-44-0	Nitrogen dioxide
11097-69-1	Chlorodiphenyl (54% Chlorine) (PCB)
12001-26-2	Mica (respirable dust)
12415-34-8	Emery
12604-58-9	Ferrovandium dust
13397-24-5	Gypsum
13463-39-3	Nickel carbonyl (as Ni)

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

CAS No.	Chemical or Trade Name
13463-39-3	Nickel, metal and insoluble compounds (as Ni)
13463-39-3	Nickel, soluble compounds (as Ni)
13463-67-7	Titanium oxide
13494-80-9	Tellurium and compounds (as Te)
14464-46-1	Silica, crystalline cristobalite, respirable dust
14484-64-1	Ferbam
14807-96-6	Talc (containing no asbestos), respirable dust
14808-60-7	Silica, crystalline quartz, respirable dust
15468-32-3	Silica, crystalline tridymite, respirable dust
17702-41-9	Decaborane
17804-35-2	Benomyl
19287-45-7	Diborane
19624-22-7	Pentaborane
20816-12-0	Osmium tetroxide (as Os)
25013-15-4	Vinyl toluene
25321-14-6	Dinitrotoluene
25639-42-3	Methylcyclohexanol
26140-60-3	Terphenyls
26499-65-0	Plaster of Paris
29191-52-4	Anisidine (o-, p-isomers)
34590-94-8	Dipropylene glycol methyl ether
53469-21-9	Chlorodiphenyl (42% Chlorine) (PCB)
55720-99-5	Chlorinated diphenyl oxide
60676-86-0	Silica, fused, respirable dust
61790-53-2	Silica, amorphous, diatomaceous earth, containing less than 1% crystalline silica
65966-93-2	Coal tar pitch volatiles
65997-15-1	Portland cement
68476-85-7	L.P.G. (Liquified petroleum gas)
93763-70-3	Perlite
112926-00-8	Silica, amorphous, precipitated and gel
not available	Chromic acid and chromates (as CrO <sub>3</sub> )
not available	Coal dust (greater than or equal to 5% SiO <sub>2</sub> ), respirable fraction
not available	Coal dust (less than 5% SiO <sub>2</sub> ), respirable fraction
not available	Coke oven emissions
not available	Cotton dust
not available	Cyanides (as CN)
not available	Fluorides (as F)
not available	Grain dust
not available	Graphite, synthetic
not available	Methyl acetylene-propadiene mixture (MAPP)
not available	N-Nitrosodimethylamine
not available	Particulates not otherwise regulated (PNOR)
not available	Phenyl ether-biphenyl mixture, vapor

**OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)  
CHEMICALS**

<b>CAS No.</b>	<b>Chemical or Trade Name</b>
not available	Rouge
not available	Soapstone, respirable dust
not available	Soapstone, total dust
not available	Talc (containing asbestos)
not available	Tremolite, asbestiform
not available	Vegetable oil mist