Toxicity and Hazard Exposure

Contents

"All substances are toxic. There is no substance without toxicity. It is solely the dose which determines toxicity."

--Paracelcus, 16th century alchemist

A chemical is called a health hazard if there is statistically significant evidence based on at least one study that indicates that acute or chronic health effects may occur in exposed employees.

When discussing the health effects of chemicals, two terms, toxicity and hazard, are often used. ***Toxicity*** is the ability of a chemical substance to produce injury once it reaches a susceptible site in or on the body. ***Hazard*** is the probability that a substance will produce injury under the conditions/manner of use. Risk of injury is the probability that a chemical will cause harm. With proper handling, even highly toxic chemicals can be used safely. Conversely, less toxic chemicals can be extremely hazardous if handled improperly.

The biological effects (beneficial, indifferent or toxic) of all chemicals are dependent on several factors: the route of exposure, rate, duration, frequency, total dose and the type of hazard.

1 Routes of Entry for Chemicals

Remember, the presence or use of a hazardous chemical in the laboratory is not sufficient for it to present a risk to your health. Risk involves exposure to a chemical. That is, the chemical must come in contact with or enter the body and reach a site where the chemical exerts its effect. The paths a chemical uses to enter the body are called routes of entry. Inhalation, skin absorption, ingestion and injection are all routes of entry for toxic chemicals. The actual health risk of a chemical depends on its toxicity and its exposure route. No matter how toxic a material is, there is little risk involved unless it enters the body. An assessment of the toxicity of the chemicals and the possible routes of entry will help determine what protective measures should be taken by workers. A chemical may be severely toxic by inhalation but pose only moderate toxicity by other routes. Thus, it is extremely important to know the chemical's toxicity by each route of entry.

1.1 Inhalation

The most common route of entry for chemical substances is through inhalation (i.e., breathing). When breathed in, gases, vapors and particles can pass into the blood-stream along with oxygen or they may also harm the tissues of the respiratory system (e.g., asbestos, silica, etc.).

Most chemicals have an odor which can be smelled at a certain concentration, called the odor threshold. Olfactory fatigue, which may occur when a worker has been exposed to high concentrations or after prolonged lower level exposure to some substances, may make an odor seem to diminish or disappear, while the danger of overexposure remains.

Overexposure symptoms may include headache, increased mucus production, and eye, nose and throat irritation. Narcotic effects, such as confusion, dizziness, drowsiness, or collapse, may result from exposure to some substances, including many common hydrocarbon solvents (e.g., toluene). In the event of overexposure, close containers, open windows or otherwise increase ventilation, and move to fresh air. If symptoms persist, seek medical attention.

Chemicals that produce vapors should only be used in a well-ventilated area or in a fume hood. Ventilation can be increased by local exhausts or fans but, occasionally, ventilation may not be adequate and a fume hood not practical, making it necessary to use a respirator. OSHA has strict requirements for respirator use which include a medical examination and a respirator fit test. The medical exam is necessary because wearing respirators increases the work of breathing which may cause health problems for some people. Also, the work environment must be evaluated to identify the concentration of the hazard and to help select the appropriate mask and filter system.

1.2 Skin and Eye Contact (Absorption)

The second most common route of entry is absorption of chemical solids, liquids, vapors, and gases through the skin and eyes. Skin contact with a chemical may produce a local reaction (e.g., burn or rash) but can result in absorption into the bloodstream with no skin reaction. Absorption into the blood may then allow the chemical to cause toxic effects on other parts of the body.

The absorption of a chemical through intact skin is influenced by the health of the skin and the properties of the chemical. Skin that is dry or cracked or has small cuts or lacerations offers less resistance. Wear gloves and other protective clothing to minimize skin exposure. Symptoms of skin exposure may include dry, whitened skin, redness and swelling, rashes or blisters, and itching. In the event of chemical contact on skin, rinse the affected area with water for at least 15 minutes, removing clothing while rinsing, if necessary. Seek medical attention if symptoms persist.

Chemical contact with eyes can be particularly dangerous, producing a painful injury or even blindness. Wearing safety goggles or a face shield can reduce the risk of eye contact. Eyes which have been in contact with chemicals should be rinsed immediately with water continuously for at least 15 minutes (see Section 5.3.a).

Contact lenses should be removed while rinsing, however, do NOT delay rinsing to remove the lenses, seconds count. Get medical attention if symptoms persist.

1.3 Ingestion

The third most common route of entry for chemicals into the body is ingestion (i.e., swallowing). Ingestion can occur by failing to wash hands before eating or drinking, eating or drinking contaminated food or beverages in the work area, or touching the mouth with contaminated hands. Workers can easily reduce the risk of ingestion by not eating, drinking, smoking (smoking is not allowed in any UW building) or storing food in the areas where chemicals are used or stored. Additionally, washing hands thoroughly after working with chemicals, even when gloves are worn, reduces the risk of cross contamination.

In the event of accidental ingestion, immediately go to the emergency room or contact the UW Hospital Poison Control Center, 262-3702, for instructions. Use the MSDS to know the exact chemical involved. Do not induce vomiting unless directed to do so by a health care professional or by instructions in the MSDS.

1.4 Injection

Another possible route of exposure to chemicals is by accidental injection which can occur by needle sticks or through accidents with broken glassware or other sharp objects that have been contaminated with chemicals. If accidental injection has occurred, wash the area with soap and water and seek medical attention, if necessary. To reduce this risk, always use caution when handling sharp objects.

2 Sites of Action

The effects of chemicals on the body are classified as local or systemic depending upon the site of action. For a chemical to express its toxic characteristics it must come in contact with a target organ. If the effect is produced directly at the point of surface contact, without first being absorbed into the circulatory system, the lesions produced are local effects. Areas commonly damaged by local effects include the eyes, skin, lung and intestinal tract surfaces. If the effects are produced in tissues as a consequence of absorption and dissemination through the circulatory system or are produced in tissues or organs away from the site of original contact, the lesions or effects are systemic effects. Chemicals can, of course, produce both types of effects

Local: effect takes place at the point of contact

Systemic: effect occurs at site other than the point of contact

3 Toxicology Overview

While the daily use of many chemicals can be perfectly safe, the body normally reacts to exposure from harmful chemicals. Toxic effects of chemicals can range from mild and reversible (e.g., a headache from a single episode of inhaling the vapors of petroleum naphtha that disappears when the victim gets fresh air) to serious and irreversible (liver or kidney damage from excessive exposures to chlorinated solvents). The chemicals used in research labs have a broad spectrum of physical, chemical, and toxicological properties and potential physiological effects. Understanding the risks associated with the use of laboratory chemicals is complicated because the risk of toxic effects is related to both the extent of exposure and the toxicity of a chemical.

Exposure to large doses of chemicals with little toxicity normally poses little risk. However, small quantities of chemicals with high toxicity or corrosivity may produce significant adverse effects. Duration and frequency of exposure also determine whether a chemical will produce harmful effects. In some instances, a single exposure to a chemical may produce poisoning. For others, repeated exposures are required to produce a toxic effect. The route of exposure (e.g., via the skin, eyes, gastrointestinal tract or respiratory tract) is crucial in assessing risk. For some chemicals, the effect on a single "target" organ may be the overriding concern.

Cumulative effects may occur if exposure is from materials that tend to build up in the body because of numerous chronic exposures. The effects are not seen until a critical body burden is reached (e.g., heavy metals).

Combinations of substances may result in toxic effects which are significantly greater than the toxic effect of either substance alone. For this reason, it is prudent to assume the product of a chemical reaction may be more toxic than the most toxic ingredient.
This section discusses some of the terminology encountered in toxicology as they relate to acute and chronic toxicity. These terms are important to understanding the toxicity information published in safety documents (e.g., Safety Data Sheets, labels) and for assessing potential chemical exposure.

Not all chemical health hazard information has been researched. The American Chemical Society's Chemical Abstracts Service (CAS) lists over ten million known chemicals. The National Institute of Occupational Safety and Health's (NIOSH`s) *Registry of Toxic Effects of Chemical Substances,* a compendium of toxicity tests, lists fewer than 200,000 chemicals. Thus, millions of chemicals have not been tested for toxicity. Additionally, most toxicity tests are for acute toxicity and toxicity information is from animal studies where the species may react differently and often unpredictably to various chemicals. Thus, some of the information is not directly applicable to humans. So, there is still much to learn about the chemical toxicity.

Fortunately, Safety Data Sheets contain adequate safety information for most commonly used chemicals. Some research laboratories may encounter the exotic, rare and newly synthesized chemicals for which toxicity data is sparse or nonexistent. This emphasizes the importance of handling all laboratory chemicals with the utmost care.
Toxicity is a property of each chemical. Any substance can be harmful to living things. But, just as there are degrees of being harmful, there are also degrees of being safe. For every chemical, there are conditions in which it can cause harm and conditions in which it does not.

3.1 Acute Toxicity

All chemicals are toxic under some condition of exposure. In order to compare the toxicity characteristics of chemicals, it is necessary to define these exposure conditions as well as the quantity involved in the exposure. Acute toxicity is the ability of a chemical to cause a harmful effect after a single exposure to the substance by any route for a short (i.e., acute) period of time (e.g., less than one day). Acute toxicity information consists of (1) lethality data, the levels of exposure (LC50) or dose (LD50) estimated to kill 50 percent of a specific population of animals under controlled conditions and (2) dose-response (mortality) relationships. On SDSs, the degree of acute toxicity is expressed by these acronyms:

LDLO The lowest dose of a material introduced by any route, other than inhalation, over any given period of time in one or more divided portions and reported to have caused death in humans or animals.

LCLO The lowest concentration of a material in air, which has been reported to have caused death in humans or animals.

LD50 Lethal Dose to 50 percent of a population (of lab animals). The amount of dose, in mg/kg of body weight, to kill one-half of the animals to which it is administered. This is widely used as an index of toxicity. The lower the LDS), the more toxic the substance.

LC50 Lethal Concentration to 50 percent of a population (of lab animals). Refers to an airborne concentration of a contaminant that will kill one-half of the population of study organisms. Used as an index of toxicity. The lower the LC50, the more toxic the substance.

Categories of acute lethal toxicity have been developed by toxicologists. An example of such a classification is given in the Classes of Acute Toxicity table.

Toxicity Class	Dose (amount of substance per kg of body weight)	Probable Oral Lethal Dose (for a 70 kg Adult Human)	Examples	Rat Oral LD_{50} of Example
Practically nontoxic	> 15 g/kg	More than 1 quart	Sucrose	29.7 g/kg
Slightly toxic	5 - 15 g/kg	Between a pint and a quart	Ethanol	14 g/kg
Moderately toxic	0.5 - 5 g/kg	Between an ounce and a pint	Sodium Chloride	3 g/kg
Very toxic	50 - 500 mg/kg	Between a teaspoonful and an ounce	Caffeine	192 mg/kg
Extremely toxic	5 - 50 mg/kg	Between 7 drops and a teaspoon	Sodium Cyanide	6.4 mg/kg
Super toxic	<5 mg/kg	A taste (less than 7 drops)	Strychnine	2.5 mg/kg

If any of the following criteria are satisfied for a particular chemical, then it is considered very toxic:

- A chemical that has a median lethal dose (LD50) of more than 50 mg per kilogram, but not more than 500 mg per kilogram of body weight when administered orally to rats.

- A chemical that has a median lethal dose (LD50) of more than 200 mg per kilogram but not more than 1000 mg per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of rabbits.
- A chemical that has a median lethal concentration (LC50) in air of more than 200 ppm but not more than 2000 ppm by volume or less of gas or vapor, or more than 2 mg per liter but not more than 20 mg per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to rats.

Additionally, if any of the following criteria are satisfied for a particular chemical, then it is considered extremely toxic:

- A chemical that has a median lethal dose (LD50) of 50 mg or less per kilogram of body weight when administered orally to rats.
- A chemical that has a median lethal dose (LD50) of 200 mg or less per kilogram of
- body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of rabbits.
- A chemical that has a median lethal concentration (LC50) in air of 200 ppm by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to rats.

3.2 Chronic Toxicity

Chronic toxicity is the toxic effect resulting from repeated, low-level daily doses over a person's or animal's lifetime. These chronic effects can result from cumulative damage to tissues sustained from each small dose, or they can result from accumulation of the toxic chemical in the body over a long period of low-level exposure (e.g., mercury, lead). Latent effects, such as carcinogenicity or mutagenicity, are examples of long term or chronic effects. The damage done from one large or multiple low-level exposures to a carcinogen is often delayed. Thus, a cancer may not show up until after a 10 to 20-year latent period has elapsed. Likewise, the effect of exposure to a mutagen may not manifest itself until the birth of offspring with malformations resulting from the mutation.

People react differently in their sensitivity to chemical exposure. This variability in sensitivity to chemicals depends on factors such as: age, sex, eating habits, physical condition, obesity, medical conditions, drinking and smoking, pregnancy, etc.

Over time, regular exposure to some substances can lead to the development of an allergic rash, breathing difficulty, or other reactions. This physical response is referred to as sensitization. Continuing exposure past this point and the effects may occur with exposure to smaller and smaller amounts of the chemical. With sensitization, the effects usually disappear soon after the exposure stops.

On the Safety Data Sheet (SDS), toxicity by route of entry is shown. Abbreviations describing the route of administration used in the toxicity studies are:

SKN applied to the skin, to test for irritation or for systemic toxicity through dermal absorption.
ORL oral route, intragastric administration, or mixed with food or water. IPR administration into the peritoneal (stomach / intestine) cavity.
SCU subcutaneous administration of the chemical. IVN intravenous administration of the chemical.
IHL administration of the chemical through inhalation.
Examples of exposure to multiple chemicals:

1) Additive effect - combined toxicity is equal to the sum of toxicity of individual chemicals.
2) Antagonistic effect combined toxicity is less than the sum of toxicity of individual chemicals.
3) Independent effect- chemical toxicities are independent of each other.
4) Potentiating effect - a chemical with a lower toxicity causes another chemical to have a higher toxicity than if the first chemical wasn't present.
5) Synergistic effect- combined toxicity is greater than the sum of toxicity of individual chemicals.

Inhalation (via the lungs) is usually the most critical route of exposure because the surface area of the lining of the lungs is as large as a tennis court, the lungs transfer chemicals directly into the bloodstream and we breathe large volumes of air. Most exposure standards are based on the inhalation route of exposure and are expressed in terms of parts per million (Ppm), as pinole substance to mole total air (0.21 mole 02 + 0.79 mole N_2), or as milligrams per cubic meter (mg/m^3) concentration in air.

3.3 Physical Class of Agent

The physical class of the substance (i.e., solubility) is also a key factor. Highly soluble materials like ammonia irritate the upper respiratory tract while relatively insoluble materials like nitrogen dioxide penetrate deep into the lung. Fat soluble materials like pesticides tend to have longer residence times in the body.

An aerosol is composed of solid or liquid particles of microscopic size dispersed in a gaseous medium. The toxic potential of an aerosol is only partly described by its concentration (mg/m^3). It is also necessary to know the particles size. Particles above 1 micrometer (1 µm) tend to deposit in the upper respiratory tract. Particles less than 1 pm in diameter enter the lung. Very small particles (<0.2 µm) are generally not deposited.

4 Hazard Exposure Guidelines

While higher exposures are generally more worrisome than lower ones, for a specific agent there may be a threshold exposure below which toxic effects do not occur. However, determining this threshold is often difficult. We know, for instance, that heavy alcohol consumption by a pregnant female can result in Fetal Alcohol Syndrome in her child. The unknown is whether there is some lesser amount of alcohol consumption which poses no risk to the fetus. For other agents there may be no safe dose; ingestion of as little as a single 50 mg capsule of thalidomide by a pregnant female can cause malformations in her child.

Individual biology can also make a difference. Each person has a different degree of susceptibility or sensitivity to the effects of chemical exposure. Additionally, most people are exposed to more than one, often many chemicals at once. Data is available on the toxic effects of individual chemicals, but simultaneous chemical exposure can result in complex interactions which we do not yet fully understand.

There is no such thing as zero exposure to a chemical. If the chemical is present in the laboratory, and you are working with it, then you are probably exposed to it at some level.

The American Conference of Governmental Industrial Hygienists (ACGIH) and the Occupational Safety and Health Administration (OSHA) have established limits for

workplace exposures. The ACGIH's Threshold Limit Values (TLVs) are guidelines for use by industrial hygienists. TLVs represent an average level of exposure that a healthy worker can be exposed to over an 8-hour work day, 40-hour work week, essentially forever, without suffering significant adverse effects. The Permissible Exposure Limits (PELs) established by OSHA are more than just guidelines, they have the force of law and employers are responsible for assuring that their employees are not exposed to levels above the PEL. In many instances, the PEL and TLV are the same number. In stances where one is lower than the other, it is prudent to maintain exposures at the lowest level achievable.

On a SDSs, you will see acronyms for standards and regulations governing workplace chemical exposure:

- IDLH: Immediately Dangerous to Life or Health: Maximum concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.
- ACGIH: American Conference of Governmental Industrial Hygienists
- TLV Threshold Limit Value: refers to airborne concentrations of substances to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Established by the ACGIH as guidelines for use by professional industrial hygienists.
- SKIN: If a significant route of exposure for a substance is through the skin, mucous membranes and eyes, either by air or direct contact, the TLV or PEL will have a "skin" notation. Examples include pesticides, carbon tetrachloride, cyanides, ethylenediamine and thallium. This additional exposure route must be considered part of the total exposure to avoid exceeding the TLV for that substance.
- TWA Time-Weighted Average: An average airborne concentration over an eight-hour work shift. Exposures may be somewhat higher or lower than the average at various times of the day as is normally the case in a work environment.
- STEL Short-term Exposure Limit: Establishes a safe exposure limit of no more than four 15-minute periods a day. Limits established to avoid: 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury. Limits are published only for compounds where toxic effects have been reported from high, short duration exposures and are typically no more than 25 - 200% higher than the TLV.
- C: If a "C" precedes the TLV, this is a ceiling exposure limit; the concentration that should not be exceeded even instantaneously.
- PEL Permissible Exposure Limit: Similar to a TLV but established by OSHA as the legal limit for employee exposure. Employers have the legal responsibility to ensure that their employees' exposures do not exceed the PELs.
- OSHA Occupational Safety and Health Administration: Federal Government agency, part of the Department of Labor, charged with ensuring the health and safety of private sector workplaces in the U.S. Establishes and enforces safety and health regulations.
- N1OSH National Institute for Occupational Safety and Health: Part of the Centers for Disease Control of the Public Health Service of the U.S. Department of Health and Human Services. It conducts research and development in Occupational Safety and Health. Advises OSHA in rulemaking and standard-setting. Does respirator testing and approvals. Supports the training of industrial hygienists and occupational health nurses and physicians
- REL Recommended Exposure Limit: Similar to a 'TLV, but established by NIOSH, not ACGIH.

Action Level: This is an OSHA term which pertains to a few substance-specific regulations. It is an airborne concentration (lower than the PEL) that, when exceeded, requires certain activities such as exposure monitoring or medical surveillance. These limits pertain primarily to the inhalation exposure route (cf., skin); so, they are airborne concentrations. For this type exposure, the lung is usually the most critical route of entry. Exposures via other routes, such as ingestion and skin absorption, must also be taken into account to determine if an excessive exposure is present.

4.1.1 Exposure Risk Assessment

The question then is: How can one gauge exposure risk? A personal risk analysis (see Form TOX-A and TOX-B) may help you better understand your risk when working with hazardous chemicals.

First, review the Safety Data Sheets (SDSs) for each of your chemicals to determine the consequences of an accident or exposure. Are the chemicals you use corrosives, carcinogens, etc.?

Second, consider the likelihood of an accident or exposure. This depends on the quantities of the chemicals used, the manner in which they are used, and the properties of the chemicals. Do you use five-gallon cans of a flammable solvent? What is its flash point? Are toxic powders and volatile chemicals used in a fume hood? How much is used? What is the degree of their toxicity?

Thirdly, an indicator of risk is accident history. Ask your principal investigator and other researchers who do similar work about accidents and exposure incidents that have occurred with chemicals you will use.

This analysis will not precisely rank your chemical risks, but it can help you assess the relative risks of the chemicals you use. Most importantly, you'll know which chemicals require extra care, and where you should focus your safety efforts.

The SDS provides a wealth of information. But, suppose there is no SDS? One can still consider the SDS hazard conditions to determine exposure risk:

- Physical state: vapor pressure, fluidity, loft ability, lipid solubility, skin absorption.
- Chemical properties: air reactivity (flammability), water reactivity (heat, splatter, ignition, gas generation), acidity / basicity, self-reactivity (explosive, polymerization) and potency as oxidizer.
- Toxicity: chronic, acute, sensitizer.

If you are concerned about the physical effect from a chemical exposure, see a physician. Information on the signs and symptoms of an overexposure can be obtained from a physician, a SDS, and the Poison Control Center.

4.1.2 Quick Guide to Hazardous Chemical Risk Assessment

The following 7-step outline, extracted from the National Research Council's Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, provides a summary of the steps that laboratory workers should use to assess the risks from handling toxic chemicals. Besides the SDS, the Prudent Practices Committee developed 88

Laboratory Chemical Safety Summaries (LCSSs) which they believe provide more appropriate information for laboratory workers. A listing of these LCSSs can be found at https://pubchemdocs.ncbi.nlm.nih.gov/lcss

1. Identify chemicals to be used and circumstances of use. Identify the chemicals involved in the proposed experiment and determine the amounts that will be used. Is the experiment to be done once, or will the chemicals be handled repeatedly? Will the experiment be conducted in an open laboratory, in an enclosed apparatus, or in a fume hood? Is it possible that new or unknown substances will be generated in the experiment? Are any of the workers involved in the experiment pregnant or likely to become pregnant? Do they have any known sensitivities to specific chemicals?
2. Consult sources of information. Consult an up-to-date SDS or LCSS for each chemical involved in the planned experiment. In cases where substances with significant or unusual potential hazards are involved, it may also be advisable to consult more detailed chemical references. Depending on the worker's level of experience and the degree of potential hazard associated with the proposed experiment, it may also be necessary to obtain the assistance of supervisors and safety professionals before proceeding with risk assessment.
3. Evaluate type of toxicity. Use the above information obtained to determine the type of toxicity associated with each chemical involved in the proposed experiment. Are any of the chemicals to be used acutely toxic or corrosive? Are any of the chemicals to be used irritants or sensitizers? Will any select carcinogens or possibly carcinogenic substances be encountered? For many substances, it will be necessary to consult the listings of carcinogens (see Appendix D) to identify chemical similarities to known carcinogens. Are any chemicals involved in the proposed experiment suspected to be reproductive or developmental toxins or neurotoxins?
4. Consider possible routes of exposure. Determine the potential routes of exposure for each chemical. Are the chemicals gases, or are they volatile enough to present a significant risk of exposure through inhalation? If liquid, can the substances be absorbed through the skin? Is it possible that dusts or aerosols will be formed in the experiment? Does the experiment involve a significant risk of inadvertent ingestion or injection of chemicals?
5. Evaluate quantitative information on toxicity. Consult the information sources to determine the LD_{50} for each chemical via the relevant routes of exposure. Determine the acute toxicity hazard level for each substance, classifying each chemical as highly toxic, moderately toxic, slightly toxic, and so forth. For substances that pose inhalation hazards, take note of the threshold limit value time-weighted average (TLV-TWA), short-term exposure limit (STEL), and permissible exposure limit (PEL) values.
6. Select appropriate procedures to minimize exposure. Use the basic prudent practices for handling chemicals, which are discussed in Chapter 4, for all work with chemicals in the laboratory. In addition, determine whether any of the chemicals to he handled in the planned experiment meet the definition of a particularly hazardous substance due to high acute toxicity, carcinogenicity, and/or reproductive toxicity. If so, consider the total amount of the substance that will be used, the expected frequency of use, the chemical's routes of exposure, and the circumstances of its use in the proposed experiment. Use this information to determine whether it is appropriate to apply the additional procedures for work with highly toxic substances and whether additional consultation with safety

professionals is warranted.

7. Prepare for contingencies. Note the signs and symptoms of exposure to the chemicals to be used in the proposed experiment. Note appropriate measures to be taken in the event of exposure or accidental release of any of the chemicals

Toxicity and Hazard Exposure

Tox-A: Initial Chemical Hazard Assessment Form

Chemical: _____

Risks = Hazards x Probability of Exposure

Health Hazards (check hazards that apply)

- ☐ Allergens/Sensitizers
- ☐ Anesthetics
- ☐ Asphyxiates
- ☐ Carcinogens
- ☐ Irritants
- ☐ Toxic
- ☐ Highly Toxic
- ☐ Other _____
- ☐ Other _____
- ☐ Other _____

Target Organ Effect

- ☐ Hepatotoxin (liver)
- ☐ Nephrotoxin (kidney)
- ☐ Neurotoxin (nervous system)
- ☐ Hematopoietic System (blood-forming cells)
- ☐ Lungs
- ☐ Reproductive Toxin – Mutagen (Chromosomal changes)
- ☐ Reproductive Toxin – Teratogen (affects unborn)
- ☐ Cutaneous Hazard (skin)
- ☐ Eye Hazard

Physical Hazards (check hazards that apply)

- ☐ Combustible Liquid
- ☐ Compressed Gas
- ☐ Explosive

Flammable

- ☐ Aerosol
- ☐ Gas
- ☐ Liquid
- ☐ Solid

Reactives

- ☐ Organic Peroxides
- ☐ Pyrophoric
- ☐ Water Reactive
- ☐ Corrosives
- ☐ Oxidizer
- ☐

Effects (check effects that apply)
(note Chronic effects should already be noted under health effects above)

Acute Effects

- ☐ Irritation
- ☐ Burning
- ☐ Nausea
- ☐ Dizziness
- ☐ Difficulty Breathing
- ☐ Sensitization (allergies)
- ☐ Other _____

Physical Effects

- ☐ Fire
- ☐ Explosion
- ☐ Excessive Temperature (hot or cold)
- ☐ Release of Pressure
- ☐ Release of Toxic/Flammable Gases or Vapors
- ☐ Other _____
- ☐ Other _____

Factors Indicating the Degree of Hazard or the Probability of Exposure

Also consider: the number of individuals exposed, their individual susceptibility and the manner of use, storage and disposal

Indicators	Factors	LESS RISKY►►►►►►►►►►►►MOR E RISKY				
Acute Health Hazard Indicators	Corrosivity (pH, oxidizer status)	pH 6-9 OR not an oxidizer	pH 5-6 or 9-10	pH 3-5 or 10-12 OR moderate	pH 1-3 or 12-14	pH <1 or >14 OR strong oxidizer
	Toxicity (LD_{50}) oral, rat (mg/kg)	>5000	500-5000	50-500	1-50	<1
	inhalation, rat (ppm)	>10,000	1,000-10,000	100-1,000	10-100	<10
Chronic Health Hazard Indicators	Excretion (bio. half-life)	minutes	hours	days	weeks	years
Exposure Hazard Indicators	Quantity	small quantities low conc.		intermediate quantities and conc.		large quantities, high conc.
	Physical Form	Solids, granules	liquids	dusts/mists	vapors, fume	gases
	Routes of Exposure	Ingestion		skin contact, ingestion		inhalation, skin contact, ingestion
	Detection/ Warning Properties	appearance,	established odor/ irritation levels, odor/ irritation less than PEL TTLV	odor/irritation	odor/ irritation Levels Not Established odor/ irritation levels above PEUT	analytical methods
	Vapor Pressure (mmHg @20°C)	<1	1-10	10-100	100-760	760
	Exposure Limits (PEL or TLV)†	>1000 ppm	100-1000 ppm	10-100 ppm	1-10 ppm	<1 ppm
	Vapor Hazard Ratio‡	<10	10-1000	1000-10,000	10,000- ' 100,000	>100,000
Flammable Hazard Indicators	Flash Point(°F)	>200	150-200	100-150	0-100	<0
	Flammable Range (0-100%)	Narrow flammable range, flammable range in higher percentage		intermediate flammable range flammable range in middle		broad flammable range, flammable range in lower percentage range

†ppm = (mg/M3)(24.45/MW)

‡[(VP at temp. of use)(10)/atmospheric pressure]/TLV or PEL (atmospheric pressure is 760 @ sea level)

Degree of Hazards Chart

	Factor Measure	Slight	Low	Moderate	High	Dangerous
Reactivity						
Oxidizer	Electro potential, Acidic	<0.5	0.75	1	1.25	> 1.5
Reducer	Electro potential, Basic	<0.75	1 .00	1.25	1.50	> 1.75
Acid	- $\log_{10}([H_3O+][A^-]/[HA])$,	> 6	5	4	3	<2
Base	- $\log_{10}([OH^-][BH^+]/[B]$,	> 6	5	4	3	<2
Aqueous pH, Acid		> 3.5	2.5	1.5	0.5	<- 0.5
Aqueous pH, Base		<10	11	12	13	>14
Flammability	Flash Point, °C	> 75	50	25	0	<- 25
Auto Ignition Temperature	°C	> 850	650	450	250	<50
Flammability Range	U.E.L. - L.E.L. %	10	30	50	70	90
Water Reactivity	Observation	hydrates	warms	heating	splatters	gas/ignition
Self-Reactivity	Energy/mass, kJ/g	<0.25	0,5	1.0	2.0	>4.0
Reaction Energy/Heat Capacity	°C	<50	100	150	200	> 250
Molar heat capacity for solids is ~ 1 Jig ˚C x [sum]Mw (g/mole), use J/mole for reaction energy. Heat capacity of water is 4.18 kJ/liter ˚C, organic solvents are - 1.6 kJ/liter °C						
Toxicity						
Inhalation Hazard	LC_{50}xt, ppm-Hr	> 10,000	5,000	2,000	6,00	<200
Ingestion, Oral	LD_{50}mg/Kg animal	>5,000	1,500	500	150	<50
Occupational	$\log_{10}$ [STEL/vp]	>0	- 1	- 2	- 3	<- 4
Bio half-life	½ burden excreted, days	<0.2	2	20	200	> 2000
Mobility						
Vapor pressure@25°C	mm of Hg	<2.5	10	45	180	> 760
Gage Pressure (cylinders)	Atmosphere	0	5	20	100	>250
Amount of	grams	<0.1	1	10	100	>1000
Something Dangerous						
Viscosity, kinematic	Stoke (cm^2/sec)	> 10	1	0.1	0.01	<0.001
(of something dangerous)	glycerol = 9	octanol = 0.1	H_20 = 0.009	Hg = 0.0011		
Friability, low	Melting Point in °C	<60	150	250		
Density, high MP, brittle, non-compact, organic crystal						

†Acid pKa and base pKb (14- pKa) hazard assessed for the case of skin or eye contact with undissolved material. Hydrofluoric and acetic acids are more dangerous that their pKa's indicate. Skin is more sensitive to aqueous base than acid, thus the factor of 3 (0.5 log) off-set.

§Use of electro potential is out of the hazard context of an oxidizer or reducer. It's oxidizer with cellulose and reducer with oxygen in air that is a better context. Potential is what is more widely available. Some markers: Acidic Oxidizers -- quinone: 0.70; nitric: 0.93; oxygen: 1.23; dichromate: 1.23; bromate: 1.42; permanganate: 1.68; peroxydisulfate: 2.0; fluorine: 2.87.
Basic Reducers -- ferrous hydroxide: 0.56; sulfite: 0.93; phosphite: 1.05; borohydride: 1.24; zinc: 1.25; phosphorus: 1.71; aluminum: 2.31; lithium: 3.04

Tox-B Chemicals that have a Specific OSHA Standard

Because of their hazards, OSHA has specific standards for exposure to

- asbestos
- coal tar pitch volatiles
- vinyl chloride
- Inorganic arsenic (& arsenate salts)
- Beryllium
- Lead
- Chromium (VI)
- Cadmium
- Benzene
- Coke Oven Emissions
- Bloodborne Pathogens
- Cotton Dust
- 1,2-dibromo-3-chloropropane
- acrylonitrile
- ethylene oxide
- formaldehyde
- Methylenedianiline
- 1,3-Butadiene
- Methylene Chloride
- Respirable Crystalline Silica

13 carcinogens including

- 4- nitrobiphenyl (92-93-3)
- alpha-naphthylamine (134-32-7)
- methyl chloromethyl ether (107-30-2)
- 3,3'-dichlorobenzidine (& salts) (91-94-1)
- bis-chloromethyl ether (542-88-1)
- beta-naphthylamine (91-59-8)
- benzidine (92-87-5)
- 4-aminodiphenyl (92-67-1)
- ethyleneimine (151-56-4)
- beta-propiolactone (57-57-8)
- 2-acetylaminofluorene (53-96-3)
- 4-dimethylaminoazobenzene (60-11-7)
- N-nitrosodimethylamine (62-75-9)

If you work with any of the above chemicals, you need to be aware of and comply with the specific OSHA standards governing their use. These standards are above those required by the OSHA laboratory standard and, in some cases, may require special signs, medical surveillance and routine air monitoring of your workplace. If you use these chemicals routinely, even for short periods of time, you must have your workplace evaluated EHS to assure that your work practices and engineering controls are enough to keep your exposures below the OSHA specified limits. The most common of these in laboratories are formaldehyde (formalin), benzene and ethylene oxide exhaust ventilation that purges the sterilizer chamber outdoors before the operator can open the chamber. This is the type of engineering control necessary to reduce ethylene oxide exposure to an acceptable level.