Toxic Chemicals- Safe Work Practices

Chemicals used in laboratories have a wide range of physical, chemical and toxicological properties that lead to adverse health effects in humans. The risks associated with their use are dependent on both the level of exposure and the inherent toxicity of the chemical. The most important factor that determines whether a substance is toxic to an individual is the relationship between the amount of the chemical reaching the target organ, and the toxic effect it produces. It is important to understand that no substance, whether considered hazardous or not, is entirely safe. All chemicals, even water, result in some toxic effect if a high enough amount (dose) comes in contact with a living organism. In contrast, even highly toxic chemicals can be relatively harmless at low doses.

The frequency at which an individual is exposed to a chemical also influences toxicity. In some cases, a single (**acute**) exposure may bring about negative health effects whereas in other cases, repeated, long-term (**chronic**) exposures may be required to produce toxic effects. Most toxic effects from chemicals are reversible, causing no permanent damage. That being said, permanent damage and even death can result if exposed to a chemical in sufficient **dose, duration or frequency**. In general, the longer an individual is in contact with a chemical, the greater the chance for acute or chronic health effects to occur. As a result, strict attention should be paid to minimizing exposure to toxic chemicals.

Exposure to chemicals in the laboratory occurs by four routes: (1) inhalation into the respiratory tract (2) absorption through the skin via dermal contact, (3) ingestion into the digestive tract, and (4) injection directly into the bloodstream. Some chemicals may cause serious health effects by one entry route, and minimal effects by another. Safety data sheets (SDSs) should indicate the toxic effects of chemicals given their route of entry into the body.

In addition to routes of entry, it is important to recognize that the combined effects of two toxic chemicals may be significantly greater than the toxic effect of either chemical alone. This

synergistic effect occurs during many chemical reactions and can lead to the generation of highly toxic compounds. Understanding the products of chemical reactions prior to engaging in active experimentation allows time to both protect individuals and control potentially hazardous conditions.

Exposure Limits

Exposure to toxic chemicals in laboratories can lead to negative health effects in susceptible individuals. As a result, the **Occupational Safety & Health Administration (OSHA)** and the **American Conference of Governmental Industrial Hygienists (ACGIH)** have established exposure limits for chemicals to protect individuals and control workplace hazards. The following exposure limits are listed below:

- ***Permissible Exposure Limits (PELs)*** are regulatory limits based on the amount or concentration of a substance in the air. In some cases, they may also contain a skin designation. Most ***PELs*** are based on an 8-hour time weighted average (TWA) exposure to which it is believed most workers may be exposed to for a working lifetime without developing serious illness. ***PELs*** are enforced by **OSHA** as a legal standard.

- ***Action level*** means a concentration designated for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance. ***Action levels*** are enforced by **OSHA** as a legal standard.

- ***Threshold Limit Values (TLVs)*** are based on the TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, for a working lifetime without adverse effect. ***TLVs*** are established by the **ACGIH** and are not regulatory or consensus standards.

- ***Short-Term Exposure Limit (STEL)*** is a 15-minute TWA exposure that should not be exceeded at any time during a workday, even if the 8-hour TWA is within the TLV–TWA. The ***STEL*** is the concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, 3) dose-rate-dependent toxic effects, or 4) narcosis of sufficient degree to increase the likelihood of accidental injury, impaired self-rescue, or materially reduced work efficiency. ***STELs*** are established by the **ACGIH** and are not regulatory or consensus standards.

- ***Threshold Limit Value- Ceiling (TLV–C)*** is the concentration that should not be exceeded during any part of the working exposure. If instantaneous measurements are not available, sampling should be conducted for the minimum period of time sufficient to detect exposures at or above the ceiling value. ***TLV–C*** values are established by the **ACGIH** and are not regulatory or consensus standards.

Exposure limits are indicated on **safety data sheets (SDSs)** present in laboratories. Since only approximately 500 ***PELs*** have been established, many chemicals used in laboratories do not have recognized exposure limits. In such cases, comparison of the chemical lacking an exposure limit to other chemicals with similar structures (e.g., hydrocarbons) or physical properties (e.g., volatile organic compounds) may be necessary. Notify your professor, supervisor or EH&S if you have questions regarding exposure limits for specific chemicals in the lab. EH&S can perform air monitoring when overexposures are suspected.

Signs & Symptoms

Signs and symptoms of chemical exposures can occur after single or repeated exposures. Some individuals develop a sensitivity (i.e. an allergic reaction) in normal tissue after repeated exposure to the certain chemicals (e.g., chromium, nickel, formaldehyde, isocyanates, etc.)
The following table is a list of common signs and symptoms of chemical exposures:

Category	System affected	Common symptoms
Dermatological	Skin, Eyes	abnormally dark or light skin, burning sensation, itching, rashes, redness, swelling
Gastrointestinal	Stomach, Intestines	diarrhea, nausea, vomiting
Hematological	Blood	anemia (fatigue, weakness)
Neurological	Brain, Spinal Cord	confusion, coma, convulsions, coordination difficulty, depression, dizziness, headache, sweating
Renal	Kidney	back pain, frequent or infrequent urination
Reproductive	Ovaries, Testes, Fetus	infertility, miscarriage
Respiratory	Nose, Trachea, Lungs	irritation, choking, coughing, runny nose, sneezing, tight chest

Individuals experiencing any of signs or symptoms of chemical exposures at UCONN should contact their professors, supervisors or EH&S prior to conducting further research in their laboratories.

Health Hazard Classes

The **Occupational Safety & Health Administration (OSHA)** classifies many toxic chemicals as posing one or more of the following harmful effects upon exposure: acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenicity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); or aspiration hazard. Each of these hazard classes leads to adverse health effects upon single or repeated exposure. The classes, pictograms and class descriptions are listed in the table below:

Hazard Class	Pictogram	Description
Acute Toxicity		***Acute toxicity*** refers to those adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.

Hazard Class	Pictogram	Description
Skin Corrosion		***Skin corrosion*** means the production of irreversible damage to the skin following the application of a test substance for up to 4 hours.
Skin Irritation		***Skin irritation*** means the production of reversible damage to the skin following the application of a test substance for up to 4 hours.
Serious Eye Damage		***Serious eye damage*** means the production of tissue damage in the eye, or serious physical decay of vision, following application of a test substance to the front surface of the eye, which is not fully reversible within 21 days of application.
Eye Irritation		***Eye irritation*** means changes in the eye following the application of a test substance to the front surface of the eye, which are fully reversible within 21 days of application.
Respiratory Sensitizer		***Respiratory sensitizer*** means a substance that induces hypersensitivity of the airways following inhalation of the substance.
Skin Sensitizer		***Skin sensitizer*** means a substance that will induce an allergic response following skin contact.
Germ Cell Mutagenicity		***Mutagen*** means an agent giving rise to an increased occurrence of mutations in populations of cells and/or organisms.

Hazard Class	Pictogram	Description
Carcinogenicity		***Carcinogen*** means a chemical substance or a mixture of chemical substances which induce cancer or increase its incidence.
Reproductive Toxicity		***Reproductive toxicity*** includes adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in offspring.
Specific Target Organ Toxicity (single or repeated exposure)		All significant health effects not included in other classes that can impair function, both reversible and irreversible, immediate and/or delayed are included in the non-lethal target organ/systemic toxicity class.
Specific Target Organ Toxicity (single or repeated exposure)		Narcotic effects and respiratory tract irritation are considered to be target organ systemic effects following a single exposure.
Aspiration Hazard		***Aspiration toxicity*** includes severe acute effects such as chemical pneumonia, varying degrees of pulmonary injury or death following aspiration.

Note: Please be aware that this list is not comprehensive. Many chemicals which **OSHA** considers physical hazards **(e.g., explosives, flammables, oxidizers, self-reactive substances, pyrophorics, water-reactive substances, self-heating substances, organic peroxides, chemicals that are corrosive to metals, etc.)** are also toxic and should be handled accordingly.

Safe Work Practices

The following measures should be taken by researchers working with toxic chemicals:

- Read the **safety data sheet (SDS)** for each toxic chemical prior to use.
- Eliminate, substitute less toxic chemicals or reduce the quantities of toxic chemicals being used if possible.
- Work with toxic chemicals in a chemical fume hood, glove box or other type of local exhaust ventilation.
- Wear personal protective equipment as indicated by safety data sheets or the lab's workplace hazard assessment form .
- Properly label all toxic chemicals.
- Store toxic chemicals in tightly sealed containers away from incompatible materials.
- Corrosive, toxic liquids should be stored below eye level.
- Do not eat, drink, smoke, chew gum or apply cosmetics in areas where toxic chemicals are present.

Additional Resources

US Environmental Protection Agency- Toxic Substances
http://www.epa.gov/lawsregs/topics/toxic.html

Occupational Safety & Health Administration- Hazardous and Toxic Substances
http://www.osha.gov/SLTC/hazardoustoxicsubstances/index.html

Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards
http://www.ehs.uconn.edu/Chemical/Prudent%20Practices%20in%20the%20Laboratory.pdf