Lab Safety Manual :

Introduction

The decisions you make concerning the use of chemicals in the laboratory should be based on an objective analysis of the hazards, rather than merely the perception of the risks involved. Once this has been accomplished, a reasonable means of controlling the hazards through experimental protocol, work practices, ventilation, use of protective clothing, etc., can be determined. In order to assess the hazards of a particular chemical, both the physical and health hazards of the chemical must be considered. Before using any chemical, the material safety data sheet (MSDS) or other appropriate resource should be reviewed to determine what conditions of use might pose a hazard. Accidents with hazardous chemicals can happen quickly and may be quite severe. The key to prevention of these accidents is awareness. Once the hazards are known, the risk of an accident may be reduced significantly by using safe work practices.

Basic Toxicology

The health effects of hazardous chemicals are often less clear than the physical hazards. Data on the health effects of chemical exposure, especially from chronic exposure, are often incomplete. When discussing the health effects of chemicals, two terms are often used interchangeably - *toxicity* and *hazard*. However, the actual meanings of these words are quite different. *Toxicity is an inherent property of a material, similar to its physical constants*. It is the ability of a chemical substance to cause an undesirable effect in a biological system. *Hazard* is the likelihood that a material will exert its toxic effects *under the conditions of use*. Thus, with proper handling, highly toxic chemicals can be used safely. Conversely, less toxic chemicals can be extremely hazardous if handled improperly.

RISK = TOXICITY × EXPOSURE

The actual health risk of a chemical is a function of the toxicity and the actual exposure. No matter how toxic the material may be, 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.

Routes of Entry

Skin and Eye Contact

The simplest way for chemicals to enter the body is through direct contact with the skin or eyes. Skin contact with a chemical may result in a local reaction, such as a burn or rash, or absorption into the bloodstream. Absorption into the bloodstream may then allow the chemical to cause toxic effects on other parts of the body. The MSDS usually includes information regarding whether or not skin absorption is a significant route of exposure.

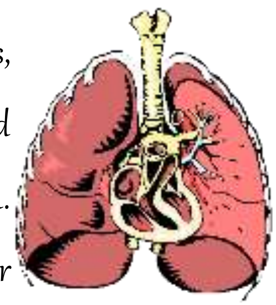
The absorption of a chemical through intact skin is influenced by the health of the skin and the properties of the chemical. Skin that is dry or cracked or has lacerations offers less resistance. Fat-soluble substances, such as many organic solvents, can easily penetrate skin and, in some instances, can alter the skin's ability to resist absorption of other substances.

Wear gloves and other protective clothing to minimize skin exposure. See *Personal Protective Equipment* for more information. Symptoms of skin exposure 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.

Avoid use of solvents for washing skin. They remove the natural protective oils from the skin and can cause irritation and inflammation. In some cases, washing with a solvent may facilitate absorption of a toxic chemical.

Chemical contact with eyes can be particularly dangerous, resulting in painful injury or loss of sight. Wearing safety goggles or a face shield can reduce the risk of eye contact. Eyes that have been in contact with chemicals should be rinsed immediately with water continuously for at least **15 minutes.** *Contact lenses should be removed while rinsing—do not delay rinsing to remove the lenses. Medical attention is necessary if symptoms persist.*

Inhalation



The respiratory tract is the most common route of entry for gases, vapors, particles, and aerosols (smoke, mists and and fumes). These materials may be transported into the lungs and exert localized effects, or be absorbed into the bloodstream. Factors that influence the absorption of these materials may include the vapor pressure of the material, solubility, particle size, its concentration in the inhaled air, and the chemical properties of the material. The vapor pressure is an indicator of how quickly a substance evaporates into the air and how high the concentration in air can become – higher concentrations in air cause greater exposure in the lungs and greater absorption in the bloodstream.

Most chemicals have an odor that is perceptible at a certain concentration, referred to as the odor threshold; however, there is no relationship between odor and toxicity. There is considerable individual variability in the perception of odor. Olfactory fatigue may occur when exposed to high concentrations or after prolonged exposure to some substances. This may cause the odor to seem to diminish or disappear, while the danger of overexposure remains.

Symptoms of over-exposure may include headaches, increased mucus production, and eye, nose and throat irritation. Narcotic effects, including confusion, dizziness, drowsiness, or collapse, may result from exposure to some substances, particularly many solvents. In the event of exposure, close containers or otherwise increase ventilation, and move to fresh air. If symptoms persist, seek medical attention.

Volatile hazardous materials should be used in a well-ventilated area, preferably a fume hood, to reduce the potential of exposure. Occasionally, ventilation may not be adequate and a fume hood may not be practical, necessitating the use of a respirator. The Occupational Safety and Health Administration Respiratory Protection Standard regulates the use of respirators; thus, use of a respirator is subject to prior review by EHS according to University policy. See *Personal Protective Equipment* for more information.

Ingestion

The gastrointestinal tract is another possible route of entry for toxic substances. Although direct ingestion of a laboratory chemical is unlikely, exposure may occur as a result of ingesting contaminated food or beverages, touching the mouth with contaminated fingers, or swallowing inhaled particles which have been cleared from the respiratory system. The possibility of exposure by this route may be reduced by not eating, drinking, smoking, or storing food in the laboratory, and by washing hands thoroughly after working with chemicals, even when gloves were worn.

Direct ingestion may occur as a result of the outdated and dangerous practice of mouth pipetting. In the event of accidental ingestion, immediately go to McCosh Health Center or contact the Poison Control Center, for instructions. Do not induce vomiting unless directed to do so by a health care provider.

Injection

The final possible route of exposure to chemicals is by injection. Injection effectively bypasses the protection provided by intact skin and provides direct access to the bloodstream, thus, to internal organ systems. Injection may occur through mishaps with syringe needles, when handling animals, or through accidents with pipettes, broken glassware or other sharp objects that have been contaminated with toxic substances.

If injection has occurred, wash the area with soap and water and seek medical attention, if necessary. Cautious use of any sharp object is always important. Substituting cannulas for syringes and wearing gloves may also reduce the possibility of injection.

Toxic Effects of Chemical Exposure

How a chemical exposure affects a person depends on many factors. The dose is the amount of a chemical that actually enters the body. The actual dose that a person receives depends on the concentration of the chemical and the frequency and duration of the exposure. The sum of all routes of exposure must be considered when determining the dose. In addition to the dose, the outcome of exposure is determined by (1) the way the chemical enters the body, (2) the physical properties of the chemical, and (3) the susceptibility of the individual receiving the dose.

Toxic Effects of Chemicals

The toxic effects of a chemical may be *local* or *systemic*. Local injuries involve the area of the body in contact with the chemical and are typically caused by reactive or corrosive chemicals, such as strong acids, alkalis or oxidizing agents. Systemic injuries involve tissues or organs unrelated to or removed from the contact site when toxins have been transported through the bloodstream. For example, methanol that has been ingested may cause blindness, while a significant skin exposure to nitrobenzene may effect the central nervous system.

Certain chemicals may affect a target organ. For example, lead primarily affects the central nervous system, kidney and red blood cells; isocyanates may induce an allergic reaction (immune system); and chloroform may cause tumors in the liver and kidneys.

It is important to distinguish between acute and chronic exposure and toxicity. *Acute* toxicity results from a single, short exposure. Effects usually appear quickly and are often reversible. *Chronic* toxicity results from repeated exposure over a long period of time. Effects are usually delayed and gradual, and may be irreversible. For example, the acute effect of alcohol exposure (ingestion) is intoxication, while the chronic effect is cirrhosis of the liver. Acute and chronic effects are distinguished in the MSDS, usually with more information about acute exposures than chronic. Relatively few chemicals have been evaluated for chronic effects, given the complexity of that type of study. Chronic exposure may have very different effects than acute exposure. Usually, studies of chronic exposure evaluate its cancer causing potential or other long-term health problems.

Evaluating Toxicity Data

Most estimates of human toxicity are based on animal studies, which may or may not relate to human toxicity. In most animal studies, the effect measured is usually death. This measure of toxicity is often expressed as an LD_{50} (lethal dose 50) – the dose required to kill 50% of the test population. The LD_{50} is usually measured in milligrams of the material per kilogram of body weight of the test animal. The concentration in air that kills half of the population is the LC_{50}.

To estimate a lethal dose for a human based on animal tests, the LD_{50} must be multiplied by the weight of an average person. Using this method, it is evident that just a few drops of a highly toxic substance, such as dioxin, may be lethal, while much larger quantities of a slightly toxic substance, such as acetone, would be necessary for the same effect.

Susceptibility of Individuals

Factors that influence the susceptibility of an individual to the effects of toxic substances include nutritional habits, physical condition, obesity, medical conditions, drinking and smoking, and pregnancy. Due to individual variation and uncertainties in estimating human health hazards, it is difficult to determine a dose of a chemical that is totally risk-free.

Regular exposure to some substances can lead to the development of an allergic rash, breathing difficulty, or other reactions. This phenomenon is referred to as *sensitization*. Over time, these effects may occur with exposure to smaller and smaller amounts of the chemical, but will disappear soon after the exposure stops. For reasons not fully understood, not everyone exposed to a sensitizer will experience this reaction. Examples of sensitizers include epoxy resins, nickel salts, isocyanates and formaldehyde.

Particularly Hazardous Substances

The OSHA Laboratory Standard defines a particularly hazardous substance as "select carcinogens", reproductive toxins, and substances that have a high degree of acute toxicity. Further information about working with Particularly Hazardous Substances is outlined in *Particularly Hazardous Substances*.

Where To Find Toxicity Information

Toxicity information may be found in Material Safety Data Sheets, under the "Health Hazard Data" section, on product labels, in the *Registry of Toxic Effects of Chemical Substances* (RTECS), or in many other sources listed in the MSDS page.