



Online Chemistry Course (OLCC)

Chemical Safety: Protecting Ourselves And Our Environment

Paper: 2

Discussion: September 12 – 18, 2004

Title: *Basic Principles of Safety in Academic Laboratories*

Author: Barbara L. Foster

Affiliation: West Virginia University, Morgantown WV

Posted: 10/16/2004

Website: http://science.widener.edu/svb/olcc_safety/index.html

OLCC COURSE

Fall 2004

September 12-18, 2004

BASIC PRINCIPLES OF SAFETY IN ACADEMIC LABORATORIES

By Barbara L. Foster

OBJECTIVE

This section is intended to establish general rules for the proper personal apparel and personal protective equipment that should be worn in a chemistry laboratory. Basic safety rules and prudent work practices that are designed to protect the student from exposure to chemical hazards in the academic laboratory are included in this section.

SUMMARY

In academia, safety education should be an integral component of each chemistry course. Because we are teaching the workforce of tomorrow, we must teach safety in every aspect of the laboratory experience and instill a philosophy of safety in our students. Safety rules and regulations provide a clear and concise foundation for our laboratory safety programs. This section provides students with guidelines that are intended to protect them from exposure to hazardous chemicals in the academic laboratory.

QUESTIONS

1. Why was the OSHA Lab Standard created?
2. What does it mean to be ANSI-approved?
3. Why do you think it is not a good idea to wear synthetic fingernails in the chemistry laboratory?
4. Why do we inspect gloves before wearing them?
5. Why is it not a good idea to walk in front of a hood that is in use?
6. How many sections are included in an ANSI-approved format for MSDS?
7. When mixing acid with water, why do we always add the acid to the water?
8. Why is it important to properly label secondary containers?
9. Why do we never pour chemicals down the drain?

GLOSSARY QUIZ

Match the term or acronym with the correct definition.

1. CHO	a. A chemical substance that induces an immediate or delayed adverse reaction by the immune system.
2. Hazardous chemical	b. The maximum acceptable concentration of a chemical in the work place air.
3. Incompatible materials	c. The ACGIH term that is used to express the maximum allowable time weighted average concentration of an airborne substance for a normal 8-hour work day or 40-hour work week.
4. Select carcinogen	d. Any liquid or solid that will ignite spontaneously in air below 54°C (130°F).
5. TLV-TWA	e. A document that contains relevant information about a material, as referenced by OSHA 29 CFR, Part 1910.1200.
6. Caustic material	f. An employee who is qualified, through training, education, and experience, to oversee the implementation of and subsequent reviews of the Chemical Hygiene Plan, per OSHA 29 CFR 1910.1450, <i>Occupational Exposure to Hazardous Chemicals in Laboratories</i> .
7. Nonflammable	g. Protective equipment (i.e., gloves, safety goggles, laboratory coat or apron, respirators) that is worn by laboratory workers to protect them from direct exposure to hazardous materials.
8. PEL	h. A material that produces genetic mutations in chromosomal DNA.
9. Flash point	i. A chemical for which there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles, that acute or chronic health effects may occur in exposed persons.
10. Teratogen	j. Materials which, when mixed, could result in the formation of toxic gases or

BASIC PRINCIPLES OF SAFETY IN ACADEMIC LABORATORIES

Barbara L. Foster, NRCC-CHO
Eberly College of Arts and Sciences
West Virginia University
Morgantown, WV

	hazardous conditions (i.e., an explosion).
11. CHP	k. A poisonous substance that has the ability to cause adverse health effects upon exposure.
12. Pyrophoric material	l. A substance that may react violently upon contact with reducing materials.
13. MSDS	m. A material that is harmful to a developing embryo at a concentration that does not have adverse effects on the pregnant female.
14. Allergen	n. A written plan that is designed to protect laboratory workers from occupational exposure to hazardous chemicals, per OSHA 29 CFR 1910.1450, <i>Occupational Exposure to Hazardous Chemicals in Laboratories</i> .
15. PPE	o. A material that can cause cancer in animals and humans.
16. Mutagen	p. The lowest temperature at which a flammable liquid produces sufficient vapor to form a readily ignitable mixture with air, either at its surface or in a container.
17. Oxidizing agent	q. A substance that has an irritating or burning effect on skin, eyes, and respiratory tract.
18. Lachrymator	r. A substance that causes growth abnormalities in embryos.
19. Embryotoxin	s. A material that is not easily ignited; a DOT hazard class for compressed gases that are not classed as flammable gases.
20. Toxic material	t. A material that has a pH greater than 12 and has a corrosive or irritating effect on living tissue at the point of contact.

SUGGESTED READINGS

American National Standards Institute; ANSI Z358.1-1998; *Emergency Eyewash and Shower Equipment*; New York, NY, 1998.

American National Standards Institute; ANSI Z400.1-1998; *Hazardous Industrial Chemicals-Material Safety Data Sheets-Preparation*; New York, NY, 1998.

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Occupational Safety and Health Administration, *Occupational Safety and Health Standards; Hazard Communication*; 29 CFR; Part 1910.1200, 1994.

Occupational Safety and Health Administration, *Occupational Safety and Health Standards; Occupational Exposure to Hazardous Chemicals in Laboratories*; 29 CFR; Part 1910.1450, 1990, <http://www.osha.gov>.

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals; National Research Council; National Academy Press: Washington, D.C., 1995.

GLOSSARY

Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
CAS	Chemical Abstracts Service
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
DOT	Department of Transportation
EPA	Environmental Protection Agency
HEPA	High Efficiency Particulate Air
IARC	International Agency for Research on Cancer
IDLH	Immediately Dangerous to Life and Health
MSDS	Material Data Safety Sheets
NEC	National Electrical Code
NFPA	National Fire Protection Association
NIH	National Institutes of Health
NIOSH	National Institute of Occupational Safety and Health
NTP	National Toxicology Program
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Level
PPE	Personal Protective Equipment
SOP	Standard Operating Procedures
TLV	Threshold Limit Value
TWA	Time Weighted Average
WHO	World Health Organization

Definitions

Acute Exposure---Short durations of exposure to high concentrations of hazardous materials in the work place.

Allergen---A chemical substance that induces an immediate or delayed adverse reaction by the immune system.

Asphyxiant---A substance that can cause suffocation.

Carcinogen---A substance that causes the development of cancerous growths in humans or is considered capable of causing cancer in humans. A substance is considered a carcinogen if:

- 1) it has been evaluated by the International Agency for Research on Cancer (IARC) and has been found to be a carcinogen or potential carcinogen;
- 2) it is listed in the National Toxicology Program's (NTP) *Annual Report on Carcinogens* as a carcinogen or potential carcinogen;
- 3) it is an OSHA-regulated carcinogen;
- 4) one study has been published which positively identifies the substance as a carcinogen.

Caustic Material---A material that has a pH greater than 12 and has a corrosive or irritating effect on living tissue at the point of contact.

Chemical Abstracts Service (CAS) Registration Number---A unique number that is assigned to a chemical as a means to identify the material.

Chemical Hygiene Officer---An employee who is qualified, through training, education, and experience, to oversee the implementation of and subsequent reviews of the Chemical Hygiene Plan, per OSHA 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*.

Chemical Hygiene Plan---A written plan that is designed to protect laboratory workers from occupational exposure to hazardous chemicals, per OSHA 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*.

Chronic Exposure---Continuous exposure over a long period of time to low concentrations of hazardous materials in the work place.

Chronic Toxicity---Adverse health effects that can be a result of long-term exposure to hazardous materials.

Combustible Material---A substance (solid, liquid, or gas) that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.

Corrosive Material---A substance that has a pH less than 2 or greater than 12 which can cause visible destruction of or irreversible alteration on physical contact with living tissue.

Embryotoxin---A material that is harmful to a developing embryo at a concentration that does not have adverse effects on the pregnant female.

Explosive Material---A material that will exhibit a rapid chemical change when subjected to a suitable ignition source (i.e., detonation, heat, friction, or impact).

Flammable---A term commonly used to describe a gas, solid, vapor, or liquid that easily ignites and rapidly burns.

Flash Point---The lowest temperature at which a flammable liquid produces sufficient vapor to form a readily ignitable mixture with air, either at its surface or in a container.

Hazardous Chemical---A chemical for which there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles, that acute or chronic health effects may occur in exposed persons.

Hazard Warning---A label on a chemical container that includes text and/or symbols to convey the hazards of the material.

High Efficiency Particulate Air (HEPA) filter---An air filter that has a 99.97% removal efficiency for 0.3 micron particles.

Immediately Dangerous to Life and Health (IDLH)---The maximum concentration of a hazardous substance from which a worker can escape within 30 minutes without irreversible health effects. IDLH is used to determine respirator selection.

Incompatible Materials---Materials which, when mixed, could result in the formation of toxic gases or hazardous conditions (i.e., an explosion).

Irritant---A substance that produces an inflammatory effect on contact with living tissue.

Lachrymator---A substance that has an irritating or burning effect on skin, eyes, and respiratory tract.

Material Safety Data Sheet---A document which contains relevant information about a material, as referenced by OSHA 29 CFR, Part 1910.1200. For consistency purposes, a 16-section standard format has been established by ANSI:

1. Material identification
2. Composition
3. Hazards identification
4. First-aid measures
5. Fire fighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls and personal protection
9. Physical and chemical properties
10. Stability and reactivity

11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Additional information

Mutagen---A material that produces genetic mutations in chromosomal DNA.

Oxidizing Agent---A substance that may react violently upon contact with reducing materials.

Nonflammable---A material that is not easily ignited; a DOT hazard class for compressed gases that are not classed as flammable gases.

Permissible Exposure Limit (PEL)---The maximum acceptable concentration of a chemical in the work place air. Commonly used exposure limits include TLV-TWA (Threshold Limit Value-Time Weighted Average), STEL (Short-Term Exposure Limit), and C (Ceiling Value).

Personal Protective Equipment (PPE)---Protective equipment (i.e., gloves, safety goggles, laboratory coat or apron, respirators) that is worn by laboratory workers to protect them from direct exposure to hazardous materials.

Physical Hazard---A substance that is a hazard of physical origin (i.e., a burn): a material that is flammable, explosive, water reactive, pyrophoric, or unstable; a combustible liquid, a compressed gas, an organic peroxide, or an oxidizer.

Poison---A substance that may injure or kill an organism, even in relatively low doses.

Pyrophoric Material---Any liquid or solid which will ignite spontaneously in air below 54°C (130°F).

Reactive Material---An explosive material, organic peroxide, pressure-generating material, or water-reactive material that vigorously polymerizes, decomposes, condenses, or becomes self-reactive when subjected to pressure, shock, or temperature changes.

Select Carcinogen---Defined in OSHA 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*, as a substance that:

- 1) is regulated by OSHA as a carcinogen;
- 2) is listed by the NTP as “known to be carcinogen”;
- 3) is listed on IARC lists as Group 1, “carcinogenic to humans”; or

4) is included on the IARC lists as Group 2A or 2B, “reasonably anticipated to be carcinogen”, because it causes statistically significant tumor incidence in animals according to the criteria that are listed in Section 2, Paragraph b.

Stench---Material that emits an extremely offensive odor.

Teratogen---A substance that causes growth abnormalities in embryos.

Threshold Limit Value---The ACGIH term that is used to express the maximum airborne concentration of a substance to which most workers can be exposed during a normal 8-hour work day or normal 40-hour work week with no adverse health effects.

TLV-Ceiling Limit---The exposure concentration of an airborne substance that must not be exceeded at any time.

TLV-Short Term Exposure Limit (STEL)---The maximum concentration of an airborne substance for a continuous exposure period of 15 minutes, with the following guidelines:

- 1) There will be a maximum of four 15-minute periods per day.
- 2) There will be at least 60 minutes between exposure periods.
- 3) The daily TLV-TWA will not be exceeded.

TLV-Time Weighted Average---The ACGIH term that is used to express the maximum allowable time weighted average concentration of an airborne substance for a normal 8-hour work day or 40-hour work week.

Toxic Material---A poisonous substance which has the ability to cause adverse health effects upon exposure.

BASIC PRINCIPLES OF SAFETY IN ACADEMIC LABORATORIES

By Barbara L. Foster

According to the Occupational Safety and Health Administration (OSHA), a hazardous chemical is a chemical for which there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles, that acute or chronic health effects may occur in exposed persons. The OSHA Lab Standard, “Occupational Exposure to Hazardous Chemicals in Laboratories”, OSHA 29 CFR 1910.1450, was created to minimize employee exposure to hazardous chemicals in the laboratory. The following safety policies and guidelines are designed to protect students from exposure to hazardous chemicals and unsafe work practices in academic laboratories.

Personal Apparel and Personal Protective Equipment (PPE)

1. Students must wear chemical splash goggles (over regular eyeglasses) that conform to the American National Standards Institute ANSI Z87.1-2003 at all times in the laboratory. Follow the institution’s policy on wearing contact lenses in the chemistry laboratory. Do not handle your contact lenses while in the laboratory.
2. Students must wear approved, chemically-resistant laboratory aprons or lab coats at all times in the laboratory.
3. Students must wear clothing that provides protection from chemical spills. Clothing which completely covers the legs must be worn at all times. Shorts and skirts that do not completely cover the leg are inappropriate apparel in the laboratory.
4. Do not wear open-backed shirts, bare midriff shirts, or shirts which expose areas of the torso in the laboratory.
5. Wear shoes which completely cover the feet. Do not wear sandals, perforated shoes, open-toed shoes, open-backed shoes, or high-heeled shoes in the laboratory.
6. Confine long hair and loose sleeves in the laboratory to avoid accidents.
7. Wear the disposable gloves that are provided in your laboratory when working with hazardous chemicals. Inspect the gloves for defects before wearing and periodically during use. Notify your instructor if you have an allergy to latex. Remove your gloves before exiting the laboratory and discard them in the appropriate waste container.
8. Avoid wearing synthetic fingernails in the chemistry laboratory. Synthetic fingernails are made of extremely flammable polymers which can burn to completion and are not easily extinguished.
9. Jewelry should not be worn in the laboratory. Dangling jewelry can become entangled in equipment and can conduct electricity. Chemicals can become trapped under the jewelry and cause injuries to the skin.

Procedures to Avoid Exposure to Hazardous Chemicals

1. For your protection, thoroughly review all proposed laboratory procedures to determine the potential health and safety hazards before you begin work. Never underestimate the hazard of a chemical. Always refer to the Material Safety Data Sheet (MSDS) and the label for guidance on chemical handling and required PPE.
2. Minimize all chemical exposure. Avoid ingestion, injection, inhalation, eye contact, and skin contact with all hazardous materials in the laboratory.
3. No chemical should ever be tasted. Do not pipette by mouth in the laboratory; use a pipette bulb or pump.
4. When you are instructed to smell a chemical, you should gently waft the vapors toward your nose using your gloved hand or a folded sheet of paper. Do not place the container directly under your nose and inhale the vapors.
5. Use the chemical fume hood when there is a possibility of release of toxic chemical vapors, dust, or gases and when working with volatile substances or flammable liquids or gases. When using the chemical fume hood:
 - The sash opening should be kept at a minimum to maximize the efficiency of the operation.
 - All chemicals and equipment should be placed at least six inches from the hood face to ensure proper airflow.
 - Use the hood when there is a possibility of release of toxic chemical vapors, dusts, or gases.
 - Keep hoods closed when not in use.
 - Do not store chemicals or equipment in a hood where work is performed.
 - Students should be discouraged from walking in front of a hood that is in use. Such behavior disrupts the airflow in front of the hood.
 - Keep your head and body outside of the hood face and listen for changes in the airflow.
 - Do not rely on the hood for protection against explosions. Plan your experiments wisely.
 - Keep the sash glass clean and do not obstruct the view of the hood with posters, decals, or other items.
6. If any chemical spills onto the skin, immediately flush the affected area with water and notify the instructor.
7. Eating, drinking, smoking, chewing gum, applying cosmetics, and using smokeless tobacco products are prohibited in the laboratory. Beverage containers, cups, bottled water, and food containers are not permitted in the laboratory. Never use laboratory glassware for eating or drinking purposes.
8. Remove gloves before exiting the laboratory. Properly dispose of used gloves. Do not reuse disposable gloves.
9. Notify your instructor if you spill any chemicals. Clean up chemical spills (including water) immediately. Do not leave spilled chemicals on the bench top or floor. At the termination of your experimental work, the desktop and student hood must be

thoroughly cleaned before you leave the laboratory. The instructor will advise you of the proper manner to dispose of the cleaning materials.

10. Notify the instructor about any sensitivities that you may have to particular chemicals prior to the start of the particular laboratory experiment.
11. Due to possible contamination of laboratory coats with chemicals, students are advised that they should not wear laboratory coats outside of the chemistry buildings and that they should not wash laboratory coats with personal clothing items.
12. Always wash your hands and arms at the end of each laboratory session before you exit the laboratory.

General Safety Guidelines for Laboratory Procedures

1. Do not enter the laboratory room without the supervision of the instructor in charge of the laboratory. Working in the laboratory without supervision by the instructor in charge is prohibited.
2. When diluting concentrated acids **always** pour the acid slowly into the water with stirring. Never add water to concentrated acids because of the danger of splattering.
3. When cutting glass tubing, always protect your hands with a towel. When inserting rods, tubing, or thermometers into stoppers, the glass must be lubricated with soapy water or glycerol. Tubing ends must always be fire-polished. Make sure that the glass is cool before you touch it. Hot glass looks just like cool glass. Do not attempt to dry glassware by inserting a towel wrapped around a glass rod.
4. Glass tubing should extend well through rubber stoppers so that no closure of the tube can occur if the rubber swells.
5. All water, gas, air, electrical, and other service connections must be made in a safe and secure manner.
6. Practical jokes, boisterous conduct, and excessive noise are prohibited. Personal audio and visual equipment should not be used in the laboratory.
7. Gas valves must be kept closed except when a burner is in use.
8. Do not heat flammable liquids with a Bunsen burner or other open flame. If in doubt about the flammability of a liquid, consult your instructor.
9. Dispose of waste chemicals in the containers that have been provided and labeled for this purpose. Do not dispose of waste chemicals in the sinks or the wastebaskets. Paper towels and gloves should be placed in the appropriate waste containers.
10. Examine all apparatus for defects before performing any experiments. Do not use damaged, cracked or otherwise defective glassware. Dispose of broken glassware in the containers provided in the laboratory. If you break a thermometer (or find a broken thermometer), report it to your instructor immediately.
11. Do not insert medicine droppers into reagent bottles unless they have been specifically supplied with the bottles.
12. Never return unused chemicals to the stock reagent bottles. Take only what you need. Use the quantities of reagents recommended in your laboratory manual. Do not waste chemicals.

BASIC PRINCIPLES OF SAFETY IN ACADEMIC LABORATORIES

Barbara L. Foster, NRCC-CHO

Eberly College of Arts and Sciences

West Virginia University

Morgantown, WV

13. Do not remove stock reagent bottles from the dispensing areas without the permission of the instructor.
14. All materials (i.e., chemicals, paper, towels, broken glass, stoppers, and rubber tubing) must be kept out of the sinks at all times to minimize the danger of plugging drains. Such items are to be kept away from positions where they might fall into the sinks or drains.
15. Maintain clean glassware. When cleaning glassware with water, wash your equipment with tap water. Use distilled water only for rinsing. Do not use more distilled water than is necessary.
16. Heavy pieces of glass apparatus and filter flasks should be supported with clamps suitably protected with rubber or plastic pads. Heavy pieces of glass apparatus that are not sitting directly on the bench top should have appropriate bottom supports, such as a rings or tripods.
17. Coats, bags and other personal items should be stored in the proper areas; not on the benchtops or in the aisle ways.
18. When heating or carrying out a reaction in a test tube, never point the test tube toward your neighbor or yourself.
19. All containers containing chemicals or solutions of any kind that are retained between laboratory sessions must be labeled so that chemistry personnel can identify the contents. The label must also contain the date and the name of the responsible person.
20. Caps must be kept firmly in place on all reagent bottles and waste containers when not in use.
21. When the fire alarm sounds you must evacuate the building via the nearest exit. Extinguish all flames and turn off all equipment, as appropriate, before exiting.
22. All personal injuries and illnesses, however slight, occurring in the laboratory must be reported immediately to the instructor in charge of the laboratory.
23. Report any accident (such as fires, explosions, a chemical spill, or the breaking of equipment) to your instructor immediately.
24. No chemical should ever be poured down the laboratory drains or placed in the wastebaskets. Properly dispose of all waste chemicals in the containers that have been provided in the laboratories.
25. Visitors, including children and pets, are not permitted to enter laboratory rooms.
26. Smoking is prohibited in all chemistry laboratories.
27. Do not take laboratory equipment, glassware, or chemicals from the laboratory room without the permission of the instructor.