5. Safety in the Chemical Laboratory

A considerable part of the work in an organic chemistry laboratory involves using materials and processes that can be dangerous if not properly handled. With careful preparation beforehand and careful use of chemicals and equipment, accidents can be avoided. Lack of intelligent preparation and careless use of chemicals and equipment can be extremely hazardous, even fatal. Therefore, you must learn to work intelligently and take the proper precautions for each experiment. Specific safety precautions are given for each experiment. Be sure to check both the text and the manual for this information. The following are some general rules for safe laboratory practice.

Preparation

Before coming to the laboratory, study the experiment and try to understand the procedure that you will be performing. Make a special note of any safety precautions. At times there will be parts that you don't understand. Be prepared to ask your instructor about these.

You need to prepare for each experiment in order to start the notebook write-up and to be ready for the quiz that is given before the experiment. A more important reason for adequate preparation is to be able to work efficiently in the laboratory. However, the most important reason for adequate preparation is so that you can work safely in the laboratory. As you prepare for the experiment you should have all of these things in mind, not just the quiz.

Personal Protective Equipment (PPE)

All students in the laboratory must wear safety goggles when anyone is working with chemical in the lab. This includes when a student across the lab is still working with chemicals even though you have finished your experiment for the day. This simple precaution can eliminate the danger of eye injury caused by you or your neighbor spattering chemicals or breaking glass. Another important protection for your eyes is to avoid rubbing your fingers in or near your eyes. Chemicals can easily be transferred from your hands to your eyes in this way.

All students are required to wear a lab coat at all times when anyone is working with chemicals in the lab. A lab coat is more than a uniform identifying you as a scientist; it affords you some protection from spills of hot or corrosive materials as well as protecting your regular clothing. Use common sense in choosing the clothes that you wear to the laboratory. Loose clothing may be more susceptible to catching on fire and may also cause accidental spills.

Typically goggles and coats do not have to be worn during the quiz and pre-lab lecture portion of the class. As soon as the experiment is begun,
everyone must wear goggles and coats until everyone has finished working will all chemicals for the day.

Never wear sandals or open-toed shoes in the laboratory. This is a requirement. Feet are especially vulnerable to anything that falls.

There is some controversy about wearing contact lenses in a chemical laboratory. In general, it is better to wear eyeglasses if you have them. Be sure to change from contacts to glasses in enough time to allow your eyes to adapt to the glasses by the start of the lab. If you must wear contacts be especially careful to wear goggles at all times and do not touch your eyes with fingers. Chemicals can get behind the lens, between it and your eye. This is very dangerous because the lens holds the chemical in contact with the eye. The lens also obstructs the cleaning of the eye and becomes difficult to remove because the eye muscles tighten in this situation. In extreme cases the contact lens can fuse to your eye.

**Response to Accidental Contact**

Avoid all direct contact between any part of your body and chemicals. Goggles, lab coats, full shoes and gloves decrease the chances of accidental contact. Some chemicals are quite innocuous while some chemicals are very hazardous. Whenever direct bodily contact is made with hazardous or unknown chemicals, the top priority is to remove the chemical and limit exposure. This is most often accomplished by **immediately removing any contaminated clothing and washing all exposed body parts.** If some chemical splashed on one’s hand, arm or foot, immediately go to the sink and wash with copious amounts of soap and water. If chemicals splashed on one’s lab coat, remove the lab coat. If hazardous chemicals seeped through the coat onto underlying clothing, remove that clothing. If chemicals are on one’s body, proceed to the safety shower and pull the ring. If any chemical enters one’s eye, proceed to the nearest eye wash and flush eyes for a full 15 minutes.

**Hazardous Chemicals**

There are many different kinds of hazards associated with various chemicals. Many chemicals are flammable; that is, they can catch on fire. (Note that the term inflammable does not mean not flammable as you might expect. It means the same thing as flammable.) Some flammable chemicals catch fire rather easily; others are not so susceptible. Some common flammable chemicals include low molecular weight ethers, alcohols, and hydrocarbons.

Some chemicals are carcinogens or cancer-causing agents. Mutagens cause mutations, which are inheritable changes in the genetic material. Teratogens cause birth defects. Lachrymators cause tearing and intense eye irritation. There are chemicals that are explosive. Some are corrosive and can cause visible destruction of skin and clothing. Others irritate the skin in other
Some chemicals that are relatively harmless individually become hazardous when mixed together. Toxic materials cause sickness or death when inhaled, ingested or absorbed.

Many common chemicals have one or more of these properties, so treat any chemical that you do not know about as potentially dangerous. Nevertheless, do not let the hazards scare you unduly. Chemicals are safe when handled in the right way, and even water is unsafe when handled the wrong way. The key is to look up chemical hazards ahead of time. Use this lab manual, the on-line notes or (even better) the Material Safety Data Sheet (MSDS) of each individual compound. A binder with MSDS is available in the laboratory. Handle chemicals in accordance with the information you find, and be especially cautious with unknown materials.

In this laboratory we have reduced the possibility of fire by eliminating the use of open flames for heating. The sand baths, Mel-Tems, and hot plates that we use can become extremely hot, however. So, beware of touching the surfaces of these items and of spilling flammable solvents or solutions on them. Be especially wary of the sand. Hot sand can cause severe burns and it does not look any different from cold sand. Although we do not use open flames in this laboratory, you must be aware of the hazards involved in using them. Never use an open flame in an organic chemistry laboratory in which flammable solvents are in use.

Do not allow any laboratory chemicals to come in contact with your skin. If you do get a chemical on your skin, immediately wash with large quantities of water. Clean up chemical spills on bench tops and balances as soon as they occur. These are common sources of chemicals that get on the skin. (Besides that, the balances are sensitive electronic instruments that are easily damaged by spilled chemicals getting into their interiors.) Be especially careful of concentrated acids and bases. Mercury spills from broken mercury thermometers are especially dangerous. Notify your instructor when these occur.

If any chemicals get into your eyes, flush them out immediately with large quantities of water from the eye wash fountain or saline solution from an eye wash bottle. Flushing should be continued for fifteen minutes and then prompt medical attention should be obtained.

Some chemical operations produce poisonous or irritating gases. When this is the case, the operation should be carried out in a working fume hood or with an appropriate trap. In this class you will be instructed when this is required. The hoods in our labs are most effective when the sash is closed. Only open them high enough to work in and lower them when you finish.

Never eat or drink in the laboratory. Do not even bring food or beverages into the laboratory. Federal inspectors even consider a food container found in a lab trash can as sufficient evidence of eating in lab and can levy heavy fines.

**Electrical Hazards**

Open flames have been eliminated from our organic chemistry laboratories, but the amount of electrical equipment has increased. Be
especially careful of the equipment on your lab bench. This includes sand baths and their controllers, Mel-Temps, and hot plates. There are burn hazards associated with all of these (as mentioned above). There is also the danger of electrical shock. Make sure that your hands are dry when handling this equipment. Clean up water spills as soon as possible, and if water has spilled on the equipment notify your instructor immediately.

Another potential hazard with the electrical equipment comes from damaged insulation on power cords. If you notice exposed wires on any of this equipment, notify your instructor immediately so it can be repaired. Do not use it until it is repaired. Much of this kind of damage is caused by the cord coming into contact with the hot surfaces of the equipment or with hot sand. Please be aware of this possibility and try to keep the cords away from heat.

**Disposal of Excess or Used Materials**

One of the reasons that many teaching laboratories have converted to microscale methods is to reduce the amount of chemical waste. However, there are still excess and waste chemicals, and it is important for the safety of individuals and the environment that the disposal of this material be done safely.

The laboratory text gives specific instructions for disposal of chemicals from each experiment. Follow these instructions unless this manual or your instructor gives you other directions. The following are some general guidelines regarding the handling of surplus materials.

One of the simplest ways to reduce the amount of waste is: **take no more material than you need from the container.** Once you have removed a chemical from its original container, it must be considered contaminated and should not be returned to the container. Therefore, take only what you need. If you should take too much of a reagent, see if anyone else in the class needs some. If not, the reagent must be properly disposed of. **Do not leave the excess lying around near the balances or elsewhere in the laboratory.**

Also, to minimize contamination as well as unpleasant odors, put the lids back on all reagent containers immediately.

Never put any solids in the sink. This includes filter paper, litmus paper, boiling chips, and sand as well as surplus solid chemicals. Dispose of paper, sand, and other harmless materials in the waste basket. Some nonhazardous chemicals can also be placed there. However, never put any chemical in the waste basket unless specifically instructed to do so by the text, manual, or instructor.

Place most waste solid and liquid chemicals and reaction products in a container placed in a fume hood for that purpose. Find the appropriate container and place the chemical in that container. If you don’t find such a container or if it is already full, consult your instructor. Do not place the material in another container unless your instructor tells you to do so. It is dangerous to mix certain reagents, so don’t place the material in the wrong container.
Glass is in a class by itself. Never put any broken glass item in a sink or waste basket. Special boxes are provided in the laboratory for glass that is broken or must be disposed of for other reasons. Put glass in these boxes only, and only put glass in these boxes.

A few liquids can be disposed of in the sink. Small samples of dilute acids and bases are in this category. Concentrated acids and bases must be diluted and neutralized, if necessary, before disposing of them in the sink. When diluting acids or bases remember to add them to water, not vice versa. In all cases in which materials can be disposed of in the sink, they must be flushed down the drain with a large quantity of water.

**Safety and First Aid Equipment**

The laboratory is equipped with several pieces of safety equipment. During the first laboratory session, your instructor will point out all of their locations and demonstrate the use of some of them. This equipment includes *fire extinguishers*, a *safety shower*, one or more *eye wash fountains*, and *first aid supplies*. Know where all of these items are located and how to use them. It is too late to learn at the time that they are needed. You must know ahead of time.

Immediately report all accidents, no matter how minor, to your instructor. In the event that your instructor is unable to assist you in an emergency, contact the stockroom supervisor, the department chairperson, or another chemistry faculty member.

Below is a summary of general safety procedures for organic chemistry students.

**GENERAL ORGANIC SAFETY CONCERNS** – Living organisms are organic assemblages and as such, organic chemicals have the propensity to cause more harm and damage than most other broad classes of chemicals. Extra care and precautions should be used when working around organic chemicals. Lack of intelligent preparation and careless use of chemicals and equipment can be extremely hazardous and even fatal. Specific precautions are given for individual experiments, while general safety measures should be followed at all times when working in the laboratory. If you are ever concerned about the safety of carrying out a procedure, stop. Ask for assistance or clarification before continuing. Do your best to avoid or minimize direct contact between any part of your body and all chemicals. Wear eye goggles, full shoes and a lab coat. These PPE (personal protective equipment) add one additional barrier layer between you and the chemicals. Wash hands before leaving the laboratory.

**CHEMICAL SPILLS ON YOUR BODY** - Remember that speed in washing to remove the chemical is most important in reducing the extent of injury. If you spill a chemical on your arms or hands, or notice a burning sensation on your arm or hands,
go IMMEDIATELY to the nearest sink and wash the affected area with copious amounts of soap and water. If you spill a large amount of chemicals on your body, remove your lab coat, if the spill went through to your clothes then go to nearest safety shower and douse yourself fully. Remove any contaminated clothing. Remain in the shower until all chemicals have been washed away.

CHEMICALS IN EYES – If a chemical gets splashed into your eyes, immediately go to the nearest eye wash station and while holding your eye open, irrigate the eye completely for at least 15 minutes. Your instructor will ensure an escort is provided to the Student Health Center or another health center.

ALLERGY/CHEMICAL SENSITIVITY – Due to the possibility of contact with chemicals, please self-notify your instructor if you have a known allergy or have a known chemical sensitivity or if you develop any of these conditions during the semester. Additional safety equipment (such as gloves) may be put in place. You may be forbidden from participating in select labs.

PREGNANCY – Some materials used in chemistry laboratories are potentially hazardous to human health, especially if used incorrectly or in certain situations. Risks to the fetus during pregnancy may be different or greater than the common hazards. If you are pregnant or become pregnant during the semester, immediately consult with your doctor about whether or not you should remain in this class. A list of all chemicals used in this laboratory is available on the organic web site. We will be happy to provide the MSDS (material safety data sheets) of any material that you request.

HEALTH CONDITIONS- If you have a condition that may impact the safety of yourself or others in the lab (such as fainting spells, seizures, tremors, etc) notify your instructor. Special safety practices may be put in place.

EYE PROTECTION - Safety goggles must be worn at all times when you or anyone else is actively working with chemicals in the laboratory. The safety goggles must have full side shields. Safety glasses are not allowed in organic lab. Do not remove your safety goggles once an experiment has begun unless specifically told to do so by your instructor. Avoid rubbing your fingers in or near your eyes when working in the lab.

FOOT PROTECTION - Only closed topped and closed toe shoes must be worn when working in the laboratory. If you look down and see a swath of skin showing, your shoes are not appropriate. Shoes should fully cover the top of ones feet. Shoes with holes (Crocs) or mesh are not allowed. Students without proper footwear will be asked to leave the lab.

BODY PROTECTION- Students are required to wear a lab coat when working in the laboratory. A lab coat provides an added layer of protection between your skin and any spills. These are available for purchase in NCF 362. Avoid wearing loose sleeves or other clothing which may drag in chemicals or catch on equipment.
CHEMICAL HEALTH HAZARDS- Chemicals can have more than one associated health hazard. Some common types of hazardous chemicals include carcinogens (cause cancer), mutagens (damage chromosomes), irritants, corrosives (cause destruction of tissue on contact), teratogen (cause birth defects), and other toxic agents (cause sickness or death through ingestion, inhalation or dermal contact). Treat all unknown materials as if they were very hazardous.

CHEMICAL SPILLS. All chemical spills should be cleaned up immediately by the proper procedure (if you do not know the correct procedure, notify your instructor for instructions).

DISPOSAL OF WASTE MATERIALS - Waste chemicals are to be discarded in the properly labeled waste container. BE SURE TO READ THE LABEL ON THE WASTE CONTAINER. Broken glass and used disposable pipettes should be placed in the broken glass container. Waste paper towels, filter paper, boiling stones and other trash should be discarded in the waste baskets.

REAGENTS- Take only as much material as is needed. Do not put excess material back in the original container. If you have excess material, see if any other student needs any, if not put it in the proper waste container. Put lids and tops back on reagent bottles after use.

PIPETTING LIQUIDS - Always use a rubber suction bulb or a syringe attached to the pipette to fill the pipette. Keep pipette in vertical position when using to prevent fluid from rolling back into bulb and contaminating next material used. NEVER USE YOUR MOUTH TO DO THE WORK OF THE SUCTION BULB OR SYRINGE.

HEATING MATERIALS- Make sure that a boiling stone or stir bar is contained in all liquids before heating. When heating materials in a test tube, always point the opening of the container away from yourself and other students in the area. Point the opening toward the back of the hood or up toward the splash guard that runs the length of the work bench. Never heat a closed (sealed) container. Never place your face over a material which is being heated. This includes liquids or solids, beakers, test tubes, and Erlenmeyer flasks. If the material “bumps”, the hot fluid can shoot out and cause chemical and/or thermal burns.

CONDITIONS OF YOUR WORK AREA - You should maintain a work area that is free of unnecessary clutter. Store all books, coats, purses, etc. in “Student Locker Area” at front of room. At conclusion of lab, replace all equipment to proper location, and wash all glassware (with soap and brush). If glassware does not come clean with soap and water, rinse with acetone. Do not leave any glassware in sink or other locations around the lab. Wipe up your work area after you conclude your work.

UNSCHEDULED LABORATORY PERIODS - Under no circumstances are you allowed to work in a laboratory alone or without proper supervision.
EATING OR DRINKING - Since there is a possibility of food substance becoming contaminated with toxic chemicals, no eating or drinking will be allowed in the laboratory. No chewing gum and no hard candy. Do not put on lipstick or make-up in lab. Never taste any chemicals from the laboratory. Do not have any bottles of consumable liquids out in the laboratory. (This includes bottled water.)

OPEN FLAMES - No open flames (Bunsen burners, lighters, matches) are allowed in the organic teaching labs. Most organic chemicals are flammable. The chance of a fire is substantially increased when open flames are present.

SMOKING - Smoking is not allowed in any building on campus.

UNAUTHORIZED EXPERIMENTS - Under no circumstances will you be allowed to conduct experiments that have not been assigned for you to do.

FIRE IN THE LABORATORY – In the event of a fire, call out “FIRE” and get away from the fire. Notify the instructor. Small, self-contained fires with limited fuel source may be extinguished by covering with a watch glass or simply allowing it to burn itself out. Small to Medium fires may be extinguished by the instructor using a fire extinguisher located in the lab. Medium to Large fires demand evacuation of the building. Pull the fire alarm, then immediately evacuate the building.

EVACUATION - In case of NCF evacuation, leave room immediately by nearest exit and proceed down the nearest stairs. Do not use the elevator.

FIRE ON A PERSON - If your clothing or hair catches fire, DO NOT RUN. Running only fans the flames. Go immediately to and use the safety shower and call out for help. Stay under the shower until the fire is out and the skin temperature has cooled down. If you are in a lab where a person is on fire, it is your responsibility to help that person get under the safety shower and assist them in any way that you can. NEVER USE A FIRE EXTINGUISHER ON A PERSON.

UNFAMILIAR CHEMICALS - Never use a chemical from an unlabeled container. Never substitute a chemical in an experiment without the instructor’s permission. Always treat unfamiliar chemicals as if they are dangerous.

FUME HOOD: Never place any body part other than your hands inside the fume hood. When working in fume hood, keep the sash line between you and the material being manipulated.

LAB ATTIRE:
Safe laboratory practices mandate proper attire for handling unknown or hazardous chemicals. Departmental policy forbids students from working in the lab if they are non-compliant with safety policy (including attire items 1-5 below). The Department is not required to provide make up labs due to safety non-compliance.

1. ALWAYS wear eye protection.
2. DO NOT wear sandals or open-topped or toe shoes.
3. If you have long, baggy sleeves roll them up or bind them close.
4. DO NOT wear nylon hose.
5. Wear a lab coat while working in lab.
This Safety Policy is by no means a complete and absolute statement of laboratory safety instructions. Your instructor will periodically point out other safety precautions.

A student who is familiar with the material on Introductory Laboratory Safety should be able to:

1. Define, recognize, and give examples of each of the following: carcinogen, teratogen, mutagen, lachrymator, corrosive, flammable, inflammable, nonflammable.
2. Describe when and how each of the following should be used: safety goggles, lab coat, fume hood, eyewash fountain, safety shower, fire extinguisher.
3. Identify the procedures for disposal of waste in the laboratory. Classifications can include: halogenated and nonhalogenated organic liquids, halogenated and nonhalogenated organic solids, broken glass, acids and bases, and ordinary (nontoxic) trash. (Additional classifications may be added for subsequent experiments).
4. Give and recognize the procedures for dealing with the following laboratory emergencies: fire, whether on a person or not; chemical spills on the floor or desktop, on a person's skin or lab coat, and in a person's eyes; cuts; burns. 
5. Carry out all of the assigned experiments in this laboratory safely, with knowledge of the material in this section in mind.

A Final Caution

The most important test of your knowledge of laboratory safety is not your responses on a quiz, but your actions in the lab. If you continuously disregard safety rules and practices, your instructor cannot allow you to remain in the laboratory since you will be a danger to yourself and others.

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