Chapter 1: Lab Safety

The Safety Rules summarize the rules students must follow in the lab to ensure the safety of themselves and other students in the lab. The reasons for these rules are detailed in the sections that follow. Strict adherence to all safety rules is essential in the organic chemistry laboratory: Anyone consciously violating safety rules will be asked to leave the laboratory immediately and no make-up session will be allowed.

The organic chemistry laboratory provides you with a unique opportunity to do the reactions that you can only read about in your lecture course. However, before you begin your laboratory experience you must learn some basic safety procedures, because chemistry laboratories are potentially dangerous. You must learn how to protect yourself from chemicals, fire, broken glassware, and electrical shock. You must know what to do in the event of a fire or other emergency in the lab room or building. Know the hazards of the chemicals you use so that you will know what level of caution to use when handling them (see Chapter 4 for more information on where to find this).

The CU organic chemistry teaching laboratories have minimized laboratory hazards by converting experiments to semi-microscale, substituting toxic chemicals with less harmful ones whenever possible, eliminating the use of Bunsen burners, and converting each student work station from a partially-enclosed mini-hood to a full fume hood.

Accidents do and will happen. When they do, you need to know what steps to take to minimize the impact. Most accidents are minor and methods of dealing with them are detailed in the following sections. In the event of a serious accident, remember that injured people are often in shock and are unable to help themselves. You should be prepared to help your neighbor if a serious accident occurs. A matter of seconds can be critical.

The plan for laboratory safety outlined in this and the next chapter is the Chemical Hygiene Plan (CHP) for the Organic Chemistry Teaching Laboratories. OSHA statutes require industrial but not necessarily academic laboratories to have a CHP.

1.1 Safety Rules Overview

You are required to follow the lab safety rules at all times or risk being expelled from the lab for the day and taking an unexcused absence. These rules include:

- Wear safety goggles. You may only remove your goggles if no one in the lab room is using chemicals or washing glassware. You may be able to borrow a spare pair of goggles from your TA's desk if you forget to bring yours. Contact lenses are strongly discouraged, but are permissible so long as you wear goggles. Make sure your goggles are approved for chemical use, and not just protection against particulate matter.
- Wear protective clothing. You should be covered from the top of your shoulder to the ground. A laboratory coat with pants is suitable, especially if you are not well-protected by the clothes you have chosen to wear to lab. A bare midriff is right at the edge of the lab bench where it can come into contact with spilled chemicals. Wear closed-toed shoes – they must cover the entire top and sides of your foot. Very loose-fitting garments, such as ties and wide sleeves, as well as long unrestricted hair, pose a hazard and must be restrained. If you come to lab in unsafe clothing and do not have anything to change into, you might be able to borrow some loaner clothes from the Lab Coordinator, although if supplies run out then you will not be allowed to perform the lab.
- Gloves are highly recommended at all times and are available for free from your TA's desk.

- Food, drink, smoking, and the use of headphones/earbuds are not allowed on the lab benches. The only acceptable place in the room to put these things is in your coat locker near the door.
- Work in your student hood at all times. Cover containers of compounds during transport through the lab.
- Prevent breakage by handling glassware with care at all times. Prevent chemical spills and glassware breakage by clamping flasks containing chemicals to a ring stand whenever possible. This is especially true for reaction and vacuum flasks.
- Handle chemical waste properly by placing hazardous wastes and broken glassware in the proper containers.
- If the fire alarm sounds, turn off any heat sources in use and leave the building immediately.
- Keep a clear pathway to the exits. Keep all personal items off the floor or close to the wall by the coatrack. Do not bring your bike or skateboard into lab.
- Never conduct experiments in the laboratory alone.
- Never conduct unauthorized experiments.
- Report any accidents or possible safety hazards to your TA immediately. This includes injuries, spills, broken glassware, or broken or worn equipment.

1.2 Personal Safety

A. Pregnancy and Chemical Exposure

Pregnant students should be aware that there are risks associated with the development of the embryo and fetus from exposure to certain chemicals. Likewise, students with certain medical conditions could also experience an adverse effect from exposure to chemicals. The Department of Chemistry recommends that you discuss the Organic Chemistry chemical list, procedures, and required safety precautions with your physician. The Department of Chemistry will work with you to discuss possible options regarding meeting the requirements of the course. Please contact the instructor of your course to discuss these options and any questions you may have.

B. Goggles

Laboratory safety goggles are the single most important piece of safety equipment you have in the lab, and must be worn whenever chemicals are in use in the organic chemistry laboratory. The only time you may be in the lab without goggles on is during recitations and lab periods which involve no chemicals (i.e., molecular modeling, NMR spectroscopy), or while your entire class is still taking a prelab quiz. When you are finished with your experiment, continue to wear your goggles until you leave the lab area. Your goggles protect you from fumes, splashes, and UV light. Simply put: you must wear goggles to prevent eye damage. Get used to it!

A frequent complaint of students is the discomfort of safety goggles and the fogging of goggle lenses. The discomfort of wearing goggles is no comparison to that of a chemical or UV burn on your eye. If your goggles fog up or you need to take them off for a period, go to the hallway outside the lab. If you are observed removing your goggles in the lab you will be reminded of the rule and your grade penalized for poor technique.

C. Personal Protection Equipment (PPE)

Personal protection equipment (PPE) includes safety goggles, face shields, proper clothing, gloves, and respirators. In most organic teaching laboratory situations, safety goggles and gloves and proper attire are sufficient PPE. Lab coats are certainly strongly advised although not required. Respirators are rarely used in teaching laboratories, although they can be used if a hood is not available, especially if you need to handle a very toxic chemical.

1. Clothing.

Worn to lab as part of your personal protection equipment; you must be covered from the top of the shoulders down. T-shirts with a minimum of short sleeves covering the shoulder and full pants is the least you may wear in lab. Loose-fitting garments, such as ties and wide sleeves, as well as long, unrestricted hair pose a hazard and must be restrained. Tank tops, belly shirts, shorts, skirts, and Capri pants are absolutely not allowed in the organic teaching labs.

2. Shoes.

Your feet must be covered with full shoes. Sandals, open-toed shoes, or ballet-style shoes which expose the top of the foot are not appropriate and will not be allowed in the chemical lab. Do not come to lab in improper footwear thinking you can wear booties; you will be told to leave and receive a zero. Foot booties do not provide adequate protection and are not allowed in the organic chemistry labs!

3. Gloves.

Gloves are highly recommended whenever handling chemicals and glassware. In the organic chemistry labs your lab fees are used to supply nitrile gloves. These gloves provide substantial protection against chemical exposure and are fairly chemical resistant during short-term exposure to common solvents. These gloves are kept on the TA's desk and are available for your use whenever you need them. While the cost of these gloves is not restrictive, they are expensive and you are urged to be economical with them. We can only provide gloves if we can afford to buy them.

1.3 Chemical Safety

The following sections overview the hazards and handling advisories for the common solvents and corrosives used in the organic chemistry lab. Specific hazard information for all chemicals used in the laboratories is given in the procedure sections of each experiment; Chapter 2 of this Handbook contains more information on where to find chemical hazard data when you are writing your prelab. A thorough discussion of the hazards of chemicals in the laboratory, MSDSs, and bottle labels is included in Chapter 2.

Organic chemicals have the potential to be more dangerous than most of the chemicals used in the general chemistry labs because the chemicals are often flammable, volatile, and/or toxic. Organic chemists also use strong acids and bases. The list of hazards for a particular chemical is sometimes long and alarming. This might lead you to believe that the organic chemistry lab is always a dangerous place in which to work. This is not the case! The hazards are real but only potential. You need to know what the hazards are so you know when to take extra precautions to minimize exposure. Organic chemists have an average life span as long as anybody else because they have learned how to handle chemicals safely.

A. Hazards of All Chemicals

In general, you should treat all chemicals as if they are harmful. Never put them in or near your mouth, nose, or eyes. Never eat any chemicals or bring food or drink to the lab. Avoid breathing all chemical vapors and wear gloves whenever handling chemicals. A part of proper lab preparation is looking up the hazards of the chemicals that you will be using in an experiment before you come to lab. Not only will this make the lab safer for you and others, but questions about chemical hazards can appear on any prelab quiz.

B. Special Concerns with Solvents

In organic chemistry, solvents are the media in which most everything is done. You dissolve chemicals in solvents to run reactions, and you use solvents during almost all purification and analytical steps. The solvents most commonly used in the teaching labs at CU are listed in Table 1-1. They vary widely in terms of flammability, volatility, and risk to your health. Throughout the semester you will be using each of these multiple times and should familiarize yourself with the risks and hazards associated with each.

Table 1-1: Hazards of some common solvents.

Solvent	Flammable?	Volatile?	Health hazards?
Acetone	yes	yes	yes
Diethyl ether	yes	yes	yes
Ethanol	yes	no	yes
Ethyl acetate	yes	yes	yes
Hexanes	yes	yes	yes
Methanol	yes	no	yes
Dichloromethane	no	yes	yes

1. Flammability.

Diethyl ether is by far the most flammable of the listed solvents. Furthermore, ether fumes are toxic and will accumulate in low areas due to their relative density in air. When working with flammable solvents, make sure that there is not an open flame anywhere in the lab room. In the organic chemistry teaching labs you will not be using Bunsen burners or open flames at any time; instead, heating mantles and hot plates are used whenever heating is required. While this helps reduce the risk of fire, you still need to avoid spilling flammable solvents on the hot surface of a heating mantle or hot plate.

2. Volatility.

Volatile solvents are those that vaporize easily; they are a potential hazard because if you breathe in a large volume of the vapors, you might experience irritation of the respiratory tract, intoxication, central

nervous system depression, drowsiness, or nausea. Of the listed solvents, diethyl ether and dichloromethane are the most volatile, followed by hexanes. Prevent accidental vapor inhalation by always working with these solvents in your student hood and always cover containers of them if you have to carry them through the lab.

3. Health hazards.

Methanol, hexanes, dichloromethane, ethyl acetate, and to a lesser extent, ethanol, acetone, and ether can cause serious harm if you have a one-time overexposure to them. If you accidentally ingest any of them in any quantity, notify your TA immediately! At the very least you can get very sick, or worse you could experience organ damage. Each has a slight contact hazard and could cause an irritation if you get it on your skin. Avoid spilling solvents on yourself, and especially on open wounds or in your eyes. Protect yourself at all times by wearing appropriate personal protective equipment, and by keeping all food and drink away from the lab benches.

C. Hazards of Corrosives

Strong acids and bases are used frequently in the organic chemistry teaching labs. The acids used include acetic, hydrochloric, sulfuric, nitric, and phosphoric. In concentrated form, each of these can cause chemical burns on your skin and is extremely harmful to your eyes. Sulfuric and nitric acids cause more severe burns than do the other acids. If you spill them on your skin, you will feel an immediate painful stinging. In addition, these acids can produce harmful fumes. Do not inhale any of these acids, as they are extremely irritating to the nasal passage and respiratory tract. As a general rule, the more dilute the acid, the less likely it is to cause harm.

The concentrated bases used in the organic labs are sodium and ammonium hydroxide. Like concentrated acids, they will cause chemical burns on your skin and tissue damage, although they do not cause an immediate stinging. Often you will not know you have spilled them on yourself until the damage is already done. Ammonium hydroxide is a severe bronchial irritant: avoid breathing these vapors.

When handling acids and bases, wear goggles, gloves, and protective clothing at all times. Work with them in your student hood and cover containers of them during transport.

D. Chemical Spills and Exposure

In all cases of chemical exposure (either in the eyes or on the skin), the best solution is to rinse the area for at least 10-15 minutes with cold water. Each lab contains an eyewash station and a safety shower for this reason. Make sure you know where they are located before you begin lab work; they are bright orange and appropriately marked.

If you spill a strong acid or base on yourself, do not attempt to neutralize it with a weaker base or acid (such as baking soda or vinegar) – this liberates a lot of heat and may cause thermal burns in addition to chemical burns. Baking soda or vinegar are fine for cleaning up chemical spills on the floor or bench top, but not on the skin or eyes.

Emergency Response: Chemicals in the eyes or on the skin

If you get chemicals in your eye(s), immediately go to the eyewash and begin flushing them with water. Hold the affected eye open to assure proper rinsing. Continue flushing for 10–15 min. Medical treatment is strongly advised after the rinsing period is complete.

If you get a small quantity of chemicals on your skin, hold the affected area under the sink and run water over it for 10-15 minutes. If you notice any burning, redness or other issues, seek medical treatment.

If you get a large quantity of chemicals on your skin, go and stand under the lab safety shower and then pull the handle.

E. Hazardous Wastes

Any chemical that you will no longer use is considered "Hazardous Waste." All such waste must be placed in the appropriate container. See Chapter 2 for more details.

1.4 Glassware, Equipment, and Electrical Safety

In the chemistry laboratory, broken glassware has the potential to do serious harm. Cuts from glassware pose not only a biohazard risk, but you risk infection and poisoning. In addition, hot glassware can cause burns. Use common sense when handling glassware. Keep glassware away from the edge of the bench. Always clamp your reaction flask and the vacuum flask securely to a ring stand to prevent them from falling over. Check each piece of glassware for hairline or star cracks before using it. When setting up any apparatus, clamp each piece of glassware securely. If you do break a piece of glassware, use a brush and dustpan to sweep up the broken glass (not your hands!) and dispose of the pieces in the broken glass receptacle in your lab.

Keep your workspace as clear and tidy as possible to minimize the chance that you will accidentally knock something over. Graduated cylinders in particular can easily be knocked over by your sleeve or elbow. Round-bottom flasks will roll away if left unattended, so you should put them onto a cork ring if you need to set them on the bench top.

If your reaction is heated, remember that the glassware or the clamps used to hold glassware can become hot enough to cause a thermal burn on your skin. Wear heavy gloves when handling hot glassware, or allow it to properly cool first.

The proper use of electrical equipment (heating mantles, Variacs, stir motors, hot plates) is required to prevent electrical shock. Check the cord and plug to make sure that it is not frayed or damaged prior to use. If you do find a piece of equipment in need of repair, turn it in to your TA right away. Always disconnect the plug from the socket by pulling firmly on the plug: Do not yank it out by the cord! Avoid spilling water onto any electrical equipment. Store electrical equipment with the cords wrapped firmly around the unit. Cords that trail across the floor are a tripping hazard.

Emergency Response: Cuts and Burns

If you cut yourself, wash the wound immediately with large amounts of cool water. If it is your neighbor who has been hurt, be prepared to help them if they are unable to help themselves. Apply direct pressure to stop the bleeding as necessary. If the bleeding is profuse, elevate the affected limb. Watch for evidence of shock (pale, clammy skin; rapid pulse and breathing; weakness) and contact your TA or the Lab Coordinator as necessary.

Thermal burns should be treated by holding the affected area under a stream of cold water for 10–15 minutes. If the skin is not broken, you may apply a pain-relieving cream. If the skin is broken, or if the burn looks particularly bad, seek medical attention.

1.5 Fire Safety

Measures have been taken to minimize the chance of a fire occurring in the organic chemistry teaching labs. The use of Bunsen burners has been eliminated and only small quantities of flammable solvents are required for any experiment. However, fires can occur from sources other than Bunsen burners. If a solvent falls onto a hot surface such as a heating mantle or a hot plate, it might ignite. Electrical fires are also possible. Or, the fire could originate outside the lab. Once a fire has started, the presence of flammable solvents makes the situation dangerous.

In the case of chemical fires, do not douse the fire with water. This can spread the burning material across a greater area. You may make things even worse if you pick up the nearest container of clear liquid, assume that it's water, and throw it onto the fire. If it turns out to be one of the many clear, flammable solvents in use in the labs (see Table 1-1), then you have only provided the fire with more fuel.

The best method of dealing with a fire depends on its size and type. In all cases, you should notify your TA immediately. If the fire gets out of control in any way, then alert the other students and evacuate the lab, pulling the fire alarm in the hallway as you leave.

A. Small Chemical Fires

If a fire is small – for instance, a small amount of spilled solvent has caught fire in your hood – the easiest way to deal with it is to cover it with a beaker or watch glass. This will cut off its supply of oxygen and probably put the fire out. After you cover the fire, move any flammable items away from it (being careful not to let any part of yourself or your clothing get too close. You should then get the fire extinguisher and stand by in case the fire does not go out on its own.

B. Large Chemical Fires

The only way to deal with large fires is with a fire extinguisher. All of the fire extinguishers in the labs are the dry-chemical type. These are very effective for any type of fire that occurs in the labs, but create a huge mess when used. In the event of an actual fire, cleanup is the last concern, but if the fire is small then covering it is a better choice.

C. Electrical Fires

If any equipment catches fire, your first response should be to unplug it if possible. If the fire continues to burn, use a fire extinguisher as described above.

Emergency Response: Clothing or Hair Fires

If your clothing, hair, or anything attached to you catches fire, the best way to put it out is with the safety shower. Stay under the flow of water for at least 5-10 minutes. If this is not an option for any reason, then you must stop, drop, and roll.

D. If the Fire Alarm Sounds

If the fire alarm sounds, all students must immediately walk out of the lab. Do not take time to gather belongings. If you are heating a reaction or using a piece of electrical equipment, you should quickly flip the power off as you are departing.

There are three exit routes out of the organic labs:

- East down the hallway and then left out the doors that face north. (Just beyond the bathrooms and the elevator.)
- Up the stairwell on the west end of the hallway and out the first-floor doors that face north.
- South along the hallway that connects Ekeley basement to Cristol basement.

Upon exiting the building, stand at least 500 feet from the building until the Police or Fire Department officials announce that it is safe to re-enter.

The planned route for exiting the building is called the Emergency Evacuation Plan (EEP). An EEP is posted in each laboratory.