7 SAFETY IN THE LABORATORY

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A laboratory is a room or a building equipped for carrying out experiments, scientific research, and measurements, or a place where drugs and chemicals are manufactured. Hazards and risks are always present in such an environment, but you can work safely in a laboratory if safety precautions and practices are understood and followed. In this chapter some aspects of laboratory safety and the handling of laboratory glassware are described.

When conducting experiments, it is essential that you plan your experimental work before coming to the laboratory. Planning of work should involve making yourself familiar with the chemicals, equipment and apparatus that you will handle and knowledge of the potential hazards of all equipment and materials used in the experiment. This will enable you to familiarise yourself with the properties of reagents, chemicals, equipment and precautions necessary for the safe conduct of experiments.

To ensure safety in a laboratory, rules are necessary to minimize risks to laboratory users and safety measures have been put in place to protect laboratory users. Some of the rules and safety measures are simple and are important to protect you, other laboratory workers, cleaners, visitors and your work.

General Precautions

Before coming to specific issues there are two general rules to be observed. The first is that you must remember **never to work alone** in a laboratory. The second is **never to eat, drink, chew gum, and store food** in any type of laboratory. The risks of contamination by ingestion (taken in through the mouth) and inhalation (taken in through the nose) are great.

Safety equipment is used to protect the laboratory users from injury or to assist in responding to an emergency. Before starting to work in a laboratory for the first time, note the positions and the types of fire extinguishers, positions of fire blankets, fire alarm, eye washing equipment, emergency showers, first aid kits and any other safety equipment available in the laboratory. You should also familiarise yourself with the electrical panels, emergency showers, and eye washes and understand the operating procedures of all safety equipment.

All laboratory workers should have some knowledge of simple first aid. For ALL chemical splashes it is best to wash with plenty of water for about 10-20 minutes. This is especially important for concentrated acids or alkali. If a chemical should splash in your eye(s), immediately flush with running water for at least 10 min.

Mercury thermometers are used frequently in experiments. Always inform your instructor if you break a thermometer. Do not try to clean mercury yourself!! Elemental mercury, also known as liquid mercury or quicksilver, found in thermometers, is toxic to humans. You must remember to report all accidents to your supervisor or a Departmental Safety Officer if available.

Protective Measures

First of all it is a good idea to identify the hazards present in the laboratory where you are working and the safety precautions necessary to protect all those who use the laboratory. Different types of hazards are present in different types of laboratories. But all chemicals can be considered to be hazardous unless handled properly. In this category are toxic chemicals, corrosive chemicals, caustic alkali and strong acids, sodium and potassium metal, mercury, organic solvents and flammable solvents and other solvents. Other hazards include pathogenic organisms that may have to be handled in a microbiology laboratory and radioactive materials found in laboratories that use radioisotopes in experiments.

Some Rules for Working in a Laboratory

Protective clothing and gear is important when working safely in a laboratory. Therefore an important rule to remember is that a **laboratory coat should be worn** when working in the laboratory. The lab coat is the first barrier to spillage of chemicals on your body. It is worn for the protection of you and your clothing. Even if you are not clumsy, someone else in the lab probably is.

It is also necessary to dress appropriately during laboratory activities. Long hair must be tied back, baggy clothing, wearing shorts and sandals should be avoided. In fact, it is best to wear **shoes that completely cover the feet**. Also remember that contact lenses should not be worn in the laboratory.

Safety goggles or glasses and gloves must be worn when conducting experiments using hazardous chemicals and/or equipment. Handling chemicals with fingers must be avoided; always use a spatula or tweezers to transfer chemicals. Protection of your hands by wearing gloves is necessary and it is good to remember that there are many different types of protective gloves, and that you need to select chemical protection gloves according to the materials or substances with which you will

work. Remember to read the specifications and use the correct type of gloves for the job you will be doing. You must also remember to remove your gloves before using instruments, telephone (which will be used by others), and before leaving the laboratory.

When measuring liquid, it is not safe to pipette by mouth. You may think that you are pipetting out only water. Even if it is just water, there is the possibility that the glassware may not be clean.Therefore you should practice and learn to use the pipette bulb or automated pipette when accurate volumes of liquids have to be measured for experiments.

Remember that experiments must be personally monitored at all times. Do not wander around the room, distract other students, startle other students or interfere with the laboratory experiments of others. These are all issues connected with safety in the laboratory.

Fire Hazards

Flammable organic solvents include light petroleum, diethyl ether, benzene, acetone, methanol and ethanol. These solvents can be handled safely, but if handled carelessly these can be extremely dangerous. Therefore read up on precautions necessary for handling different types of organic liquids, and also sodium and potassium, if you are required to use them in your experiments. Water should never be used to extinguish fires from organic solvents and sodium and potassium.

Vapours from organic compounds, e.g. diethyl ether, can form explosive mixtures with air or oxygen. It should be remembered that vapours of organic solvents are heavier than air and will flow along a bench to be ignited by a flame some distance away. Organic liquids should be heated using an electrically heated water bath rather than a gas flame.

You should find out where the fire alarm and the exits are located. It is also good to make sure that you have unobstructed access to all exits and fire extinguishers. Extinguishers delivering a stream of carbon dioxide are preferred for most fires in chemical laboratories. The carbon dioxide fire extinguishers are also safer with sodium and potassium fires. Make sure you know how to operate the fire extinguishers in your laboratory. Only a very small fire can be extinguished with a cloth or towel. Sand is also sometimes used to extinguish laboratory fires by scattering sand on the fire. The sand acts by smothering the flame. One disadvantage of using sand will be that there is a large amount of sand to be cleaned up afterwards.

Using Laboratory Glassware

Scientific experiments especially in chemistry and biology laboratories use different types of laboratory glassware. Equipment made of glass is relatively inert, transparent and heat resistant. Laboratory glassware needs careful handling because improper use may result in serious injuries to laboratory workers.

Glassware must be checked each time before use. Chipped, cracked or dirty glassware could cause the glassware to break during use and cause serious injury to you and others in the lab. Hot glassware should not be immersed in cold water because this will cause the glassware to shatter. Also you must remember that heated glassware remains very hot for a long time. The glassware should be set aside in a designated place to cool and then picked up carefully. Tongs or heat protective gloves maybe used to pick up heated glassware.

Broken glassware can cause serious cuts and injuries. They should not be handled with bare hands. A brush and dustpan can be used to clean up broken glass. Broken pieces of glass should be placed in containers designated for glass disposal.

Cleaning Laboratory Glassware

Laboratory glassware will be used for many of your experiments and include different types of flasks, beakers, burettes and pipettes. Clean glassware is an essential requirement of good laboratory technique. Incorrect results will be obtained if dirty glassware is used and it is essential that glassware must be physically and chemically clean. In many cases, it must be bacteriologically clean or sterile.

The glassware is soaked in a detergent solution to remove grease and loosen most contamination. Large particles can be removed mechanically, by scrubbing with a brush or scouring pad. Or these two steps may be combined by sonicating the glassware in a hot detergent solution. Solvents known to dissolve the contamination are used to rinse the glassware and remove the last traces of contaminants. Acetone is often used for a final rinse of sensitive or urgently needed glassware because the solvent is miscible with water, and helps dilute and wash away remaining water from the glassware.

If glassware has been used for water insoluble solutions (e.g. solutions in hexane or chloroform), they can be rinsed 2-3 times with ethanol or acetone, rinsed 3-4 times with distilled water, and then dried. After washing, glassware is often dried by

suspending it upside down to drip dry on racks. In some situations other solvents need to be used for the initial rinse. These include concentrated acids such as HCl or H_2SO_4. This should be carried out in a fume hood, after which the glassware is rinsed many times with tap water and then rinsed 3-4 times with distilled water.

The initial rinse may sometimes require, 6M NaOH or concentrated NH_4OH. This is carried out in a fume hood and afterwards the glassware is rinsed many times with tap water and then rinsed 3-4 times with distilled water. Similarly either a weakly acidic solution such as acetic acid solutions or dilutions of strong acids such as 0.1M or 1M HCl or H_2SO_4 or weak bases (e.g. NH_4OH) or dilutions of strong bases such as 0.1M and 1M NaOH may be used for the initial rinse. In all cases the glassware is then rinsed many times with tap water and then rinsed 3-4 times with distilled water before putting the glassware away. After washing, glassware is often dried by suspending it upside down to drip dry on racks.

All glassware must be absolutely grease-free. The safest criterion for cleanliness is when there is uniform wetting of the surface by distilled water. This is especially important in glassware used for measuring the volume of liquids. Grease and other contaminating materials will prevent the glass from becoming uniformly wetted. Grease in pipettes and burettes, will distort the meniscus and the correct adjustments cannot be made. The presence of small amounts of impurities may also alter the meniscus and affect the volume of reagent delivered for your experiment. It is generally easier to clean glassware if you do it immediately after using the glassware for your experiment. If a thorough cleaning is not possible immediately, put glassware to soak in water. If glassware is not cleaned immediately, it may become impossible to remove the residue.

For glassware that is very dirty, a cleaning powder with a mild abrasive action will give more satisfactory results. The abrasive should not scratch during washing and all parts of the glassware should be thoroughly scrubbed with a brush. This means that a full set of brushes must be at hand - brushes to fit large and small test tubes, burettes, funnels, graduated cylinder and various sizes of flasks and bottles.

Detergents that are designed for laboratory glassware are preferable to any dish-washing detergent you might use on dishes at home. Most of the time, detergent and tap water are neither required nor desirable. You can rinse the glassware with the proper solvent (water- miscible), and then finish up by rinsing two or three times with distilled water. For precision chemical tests, new glassware should be soaked several hours in acid water (a 1% solution of hydrochloric or nitric acid) before washing. It is better to use brushes with wooden or plastic handles as they will not scratch or abrade the glass surface.

Safe use of Chromic Acid

Chromic acid cleaning solution must be used if glassware becomes clouded or dirty or contains coagulated organic matter. The dichromate should be handled with extreme care because it is corrosive and carcinogenic. When washing with chromic acid solution, the item may either be rinsed with the cleaning solution or it may be filled with the solution and allowed to stand. The length of time it is allowed to stand depends on the amount of contamination on the glassware. Relatively clean glassware may require only a few minutes, but if particles of dirt are present then it may be necessary to let the glassware stand all night.

Due to the intense corrosive action of the chromic acid solution, it is a good practice to place the stock bottle, as well as the glassware being treated, in flat glass pans or pans made from lead or coated with lead, or plastic polymer pans that are found to be compatible with the concentration of chromic acid you use. Extra care must be taken to ensure chromic acid solution is disposed of properly to the environment. To reduce hazards from acidity of chromic acid waste, it can be subjected to change or increase of pH by using a suitable base (sodium carbonate) before releasing to the environment. However, hazards from chromium pose a serious threat to health. Special types of precipitates may require removal with nitric acid, *aqua regia* or fuming sulphuric acid. These are very corrosive substances and should be used only when required.

Chromic Acid Cleaning Solution

Chromic acid is not a popular cleaning solution, because chromium is classified as a carcinogen. It is still used occasionally despite the careful handling that it requires, because it is effective at removing cloudy stains from glass that no other cleaner does. To make a chromic acid cleaning solution, place a clean 1 L glass beaker in a glass pan or trough to prevent damage from accidental spills. Wear rubber gloves and introduce the powdered sodium dichromate (20 g) into the 1 L glass beaker. Mix in a small amount of water to form a paste, and stir thoroughly with a glass stirring rod. Continue to stir the mixture while slowly adding 300 ml of concentrated sulphuric acid to the beaker. Allow to cool. Then carefully pour the solution from the beaker into a glass bottle and replace the stopper.

Chromic acid bath is not used in laboratories anymore because of the well known toxicity of Cr(VI) and a base bath consisting of alcoholic KOH is used instead. Glassware is immersed or allowed to stand overnight in the base bath in a suitable plastic container (basin or a bucket). The glassware is rinsed under tap water; in some cases it is washed with a very dilute solution of acid (preferably HCl) prior to washing under tap water.

Base-bath Cleaning Solution

A typical base bath cleaning solution is prepared by placing approximately 200-300 g of solid KOH pellets (sometimes NaOH is substituted) in a large plastic container and adding 4 L of ethanol (or preferably isopropyl alcohol). Afterwards, 1 L of de-ionized water is carefully added. The container is allowed to stand (in the sink) until the KOH is dissolved and the solution has cooled to room temperature. Replace the cover of the plastic container and store it in a safe place (under the sink area). Label the container with the current date and a sign that says 'DANGER: BASE-BATH SOLUTION'. Wear safety gear such as thick black gloves, a rubber apron, eye protection, and a face shield. Always use an apron, eye protection, and thick black gloves when handling glassware around the base bath. Rinse gloves after use. This base bath is highly caustic.

The disadvantage of this base bath is that it tends to evaporate over time and is flammable. It is better to wash your dirty glassware as soon as it is produced– it is much easier to wash before the dirt dries.

Good Housekeeping

Finally it is important to observe good housekeeping practices and general tidiness. A tidy laboratory avoids accidents. Reagent bottles must be stoppered and immediately replaced on reagent shelves after use and unused apparatus replaced in cupboards. An unnecessarily crowded bench can lead to spillages and accidents, and are examples of bad housekeeping. Keep your own workplace tidy, clear up waste, deal with washing up and put things away as you finish with them. Make sure everything is safe before you leave the laboratory. With these practices you ensure your own safety and that of others.