WORKING WITH FLAMMABLE CHEMICALS

All laboratory personnel should know the properties of chemicals they are handling as well as have a basic understanding of how these properties might be affected by the variety of conditions found in the laboratory.

General prudent practices include minimizing the amounts used, storing chemicals properly, keeping appropriate fire extinguishing equipment readily available, physically separating flammable materials from other operations and sources of ignition, properly grounding static sources of ignition, and using the least hazardous alternative available.

Ignition sources should be eliminated from any area where flammable substances are handled. Open flames, such as Bunsen burners, matches, and smoking tobacco, are obvious ignition sources. Gas burners should not be used as a source of heat in any laboratory where flammable substances are used. Less obvious ignition sources include gas-fired space heating or water-heating equipment and electrical equipment, such as stirring devices, motors, relays, and switches, which can all produce sparks that will ignite flammable vapors. Because the location of this equipment is often fixed, operations with flammable substances may have to be carried out elsewhere. Even low-level sources of ignition, such as hot plates, steam lines, or other hot surfaces, can provide a sufficiently energetic ignition source for the most flammable substances in general laboratory use, such as diethyl ether and carbon disulfide.

Flammable substances that require low-temperature storage should be stored only in refrigerators designed for that purpose. Ordinary refrigerators are a hazard because of the presence of potential ignition sources, such as switches, relays, and, possibly, sparking fan motors, and should never be used for storing chemicals. When transferring flammable liquids in metal containers, sparks from accumulated static charge must be avoided by grounding. Fire hazards posed by water-reactive substances such as alkali metals and metal hydrides, pyrophoric substances such as metal alkyls, strong oxidizers such as perchloric acid, and flammable gases such as acetylene require procedures beyond the standard prudent practices for handling chemicals described here

1. **Flammable Materials**
    - **a.** The basic precautions for safe handling of flammable materials include the following:
        i. Handle flammable substances only in areas free of ignition sources. Besides open flames, ignition sources include electrical equipment (especially motors), static electricity, and, for some materials (e.g., carbon disulfide), even hot surfaces. Check the

work area for flames or ignition sources before using a flammable substance. Before igniting a flame, check for the presence of a flammable substance.

ii. Never heat flammable substances with an open flame. Preferred heat sources include steam baths, water baths, oil and wax baths, salt and sand baths, heating mantles, and hot air or nitrogen baths.

iii. Ventilation by diluting the vapors until they are no longer flammable is one of the most effective ways to prevent the formation of flammable gaseous mixtures. Use appropriate and safe exhaust whenever appreciable quantities of flammable substances are transferred from one container to another, allowed to stand in open containers, heated in open containers, or handled in any other way. In using dilution techniques, make certain that equipment (e.g., fans) used to provide dilution is explosion proof and that sparking items are located outside the air stream.

iv. Keep containers of flammable substances tightly closed at all times when not in use.

v. Use only refrigeration equipment certified for storage of flammable materials.

vi. Use the smallest quantities of flammable substances compatible with the need, and, especially when the flammable liquid must be stored in glass, purchase the smallest useful size bottle.

2. Flammable Liquids

a. Flammable liquids burn only when their vapor is mixed with air in the appropriate concentration. Therefore, such liquids should always be handled so as to minimize the creation of flammable vapor concentrations.

b. Dilution of flammable vapors by ventilation is an important means of avoiding flammable concentrations. Containers of liquids should be kept closed except during transfer of contents. Transfers should be carried out only in fume hoods or in other areas where ventilation is sufficient to avoid a buildup of flammable vapor concentrations. Spillage or breakage of vessels or containers of flammable liquids or sudden eruptions from nucleation of heated liquid can result in a sudden release of vapor, which will produce an unexpected quantity of flammable vapor.

c. Metal lines and vessels discharging flammable liquids should be grounded properly and also grounded to discharge static electricity. For instance, when transferring flammable liquids in metal equipment, avoid static-generated sparks by grounding and the use of ground straps. Development of static electricity is related closely to the level of humidity and may become a problem on very cold, dry winter days. When nonmetallic containers (especially plastic) are used, the contact should be made directly to the liquid with the grounding device rather than to the container. In the rare circumstance that static electricity cannot be avoided, all processes should be carried out as slowly as possible to give the

accumulated charge time to disperse, or should be handled in an inert atmosphere.

d. Note that vapors of many flammable liquids are heavier than air and capable of traveling considerable distances along the floor. This possibility should be recognized, and special note should be taken of ignition sources at a lower level than that at which the substance is being used. Close attention should be given to nearby potential sources of ignition.

3. Flammable Gases

a. Leakage or escape of flammable gases can produce an explosive atmosphere in the laboratory. Acetylene, hydrogen, ammonia, hydrogen sulfide, propane, and carbon monoxide are especially hazardous. Acetylene, methane, and hydrogen have very wide flammability limits, which adds greatly to their potential fire and explosion hazard. Installation of flash arresters on hydrogen cylinders is recommended. Prior to introduction of a flammable gas into a reaction vessel, the equipment should be purged by evacuation or with an inert gas. The flush cycle should be repeated three times to reduce residual oxygen to about 1%.

4. Catalyst Ignition of Flammable Materials

a. Palladium or platinum on carbon, platinum oxide, Raney nickel, and other hydrogenation catalysts should be filtered carefully from hydrogenation reaction mixtures. The recovered catalyst is usually saturated with hydrogen, is highly reactive, and, thus, inflames spontaneously on exposure to air. Especially for large-scale reactions, the filter cake should not be allowed to become dry. The funnel containing the still-moist catalyst filter cake should be put into a water bath immediately after completion of the filtration. Use of a purge gas (nitrogen or argon) is strongly recommended for hydrogenation procedures so that the catalyst can then be filtered and handled under an inert atmosphere.