Office of Research Safety
Laboratory Safety Manual
806 Chemical Storage and Handling

1. Proper chemical storage and transport is extremely important in order to maximize personal safety with respect to chemical spills, chemical incompatibilities, and fire or explosion control.
    1. Common examples of improper storage practices.
        1. Chemicals are stored in alphabetical order by name. It is much better to store chemicals according to the hazard class.
        2. Chemicals are stored in a laboratory hood while the hood is used for other designated purposes.
        3. Chemicals are stored on shelves above eye level.
        4. Storage shelves are so crowded that it would be impossible to put even one more container on the crowded shelf, or so crowded that when a single bottle is to be removed, other nearby containers must be moved, or themselves removed, to get at the bottle of interest.
        5. Chemicals are put on laboratory bench tops and not returned for several days, long after their usefulness on the bench top has past.
        6. Tiers of shelves are not adequately secured, and can topple easily.
        7. Inventory control is either poor or non-existent; many containers are not identified with appropriate information.
        8. Chemical bottles are allowed to deteriorate due to corrosion. Leaks may develop.

2. Transporting Chemicals Many incidents that occur in laboratories are the result of improperly carrying chemicals from one place to another or from the transferring of chemicals from one container to another. Laboratories use many chemicals that may pose a threat to personal injury when mishandled; therefore it is best to practice safety with regards to all chemicals in a laboratory.
    1. Transporting large bottles of acids, solvents, or any other liquids should be done with the use of a cart. However, if a cart is not available for such use, only one bottle at a time should be transported with both hands: one on the neck of the bottle, while the other is placed underneath of the bottle. The use of bottle carries is highly recommended. Bottles should not be picked up by the cap or by the glass ring near the neck of the bottle.
    2. If a cart is used for transporting chemicals, the cart should be stable. Bottles should not be placed near the edge of the cart, near each other nor near other glassware during transport. Incompatible chemicals should not be placed on the same cart. (Please see incompatibility chart of this manual)
    3. In order to avoid exposure to passengers on elevators, freight-only elevators should be used when transporting chemicals.

3. Storing Chemicals
    1. Specific instructions on chemical storage may be obtained from the MSDS or on the container label.
    2. Ensure that all containers are in good condition and are properly labeled, including the date of purchase.
    3. Date all containers when opened.
    4. Store incompatible chemicals separately, as opposed to alphabetically. Incompatible chemicals should not be stored close to each other.
    5. Ensure that all storage locations are dry and adequately ventilated.
    6. Secure all storage shelves and cabinets to prevent tipping. Shelves should not be overloaded.
    7. Liquid chemicals should be placed below eye level.
    8. Flammable liquids should be stored in approved safety cabinets.
    9. The date of purchase, as well as the date of opening, of each peroxide forming chemical should be indicated on the corresponding container.
    10. Secure gas cylinders away from heat sources.
    11. All chemicals in a lab should have a definite storage place and should be returned to this place after being used.
    12. Chemicals should never be stored on the floor.
    13. Appropriate containers, such as those used in experiments, for storage or for waste, should be used according to the type of chemical. Often the MSDS will provide the specific information.
    14. Containers must be checked often (at least weekly) for any signs of chemical leakage.
    15. All containers must have caps and covers that are securely in place whenever the container is not in use.
    16. Chemicals should be stored as close as possible to the area where they are used in order to minimize the distance that the chemical is transported.

17. Keep chemical inventory to a minimum and do not store excess quantities of any hazardous materials.
18. Separate all chemicals according to compatibility groups and store them in labeled storage areas or cabinets.
19. Containers must be in good condition and compatible with its contents. Degraded, spilled or leaking containers must be disposed of as hazardous waste.
20. All containers must be legibly labeled with chemical name, concentration, and a hazard warning. Abbreviations may be used if definitions are posted.
21. Extra labeling is required for high hazard materials requiring specific storage conditions - peroxide formers, air and water reactives, and select agents.
22. Peroxide formers and other chemicals that degrade over time must be dated when received and opened and disposed of within 1 year or tested for the presence of organic peroxides - see Guidelines Work with Organic Peroxide Forming Materials for more information.
23. Avoid storing excess quantities of flammable materials and use a flammable storage cabinet where necessary (see sheet).
24. Do not keep flammable materials in a "domestic: or household refrigerator". Use a flammable storage refrigerator (see sheet). Refrigerators should have the correct label.
25. Maintain an accurate chemical inventory by keeping CisPro up to date.
26. In shared areas, space and equipment should be labeled with the user and lab name.

4. KSU Chemical Compatibility Storage Guidelines
    1. Separate each of the following classes of chemicals from each other by storing in separate cabinets or by using appropriate tubs or containers. Polypropylene tubs are commonly used for this purpose. All containers should be clearly labeled, and all storage locations should be labeled according to compatibility group.
    2. It is important that all lab personnel understand lab procedures for storage of hazardous materials, including where these materials are kept in the lab.
    3. **Mineral (Inorganic) Acids -** Examples: hydrochloric acid, sulfuric acid, phosphoric acid, boric acid, and hydrobromic acid.
    4. **Oxidizers -** Examples: bromic acid, perchloric acid, chromic acid, nitric acid, many perchlorates, permanganates, bromine, chlorine, fluorine, silver nitrate.
        1. Oxidizers should not be stored directly on wooden shelves or on paper shelf liners, spills may react and ignite spontaneously.
        2. Perchloric acid presents special hazards; it must be isolated from oxidizable materials and dehydrating agents..
        3. Hypochlorite solutions (e.g., bleach) are oxidizers; however, they will release chlorine gas on contact with acids, so store them separately.
    5. **Bases/Caustics -** Examples: aqueous ammonia, ammonium hydroxide, potassium hydroxide, and sodium hydroxide.
    6. **Organic Solvents/Acids -** Examples: acetone, methanol, isopropyl ether, methylene chloride, carbon tetrachloride, acetic acid, citric acid, benzene, tetrahydrofuran.
    7. If space is limited, labs may wish to separate flammable and non-flammable organic liquids in flammable storage cabinets.
    8. **Highly Toxic/Carcinogenic -** Examples: sodium azide, acrolein, arsenic pentoxide, pentachlorophenol, hydrazine, botulinum toxin, acrylamide, methyl isocyanate, phorbol esters.
    9. **Pyrophoric Materials -** Examples: diethyl aluminum chloride, lithium, white or yellow phosphorus, trimethyl aluminum.
    10. **General "Dry" Lab Chemicals -** Examples: This would include many of the relatively innocuous or unreactive materials commonly found in laboratories.
    11. **Gases -**Segregate according to hazard class. Acutely toxic and toxic gases should be stored in gas cabinets or fume hoods. Cylinders should be double-chained or double-strapped to a substantial, fixed surface. Cylinders should be turned off at the cylinder valve when not in use and should be capped when stored. See SB Gas Cylinders.
    12. **Water Reactives -** Examples: sodium, potassium, calcium, aluminum tribromide, calcium oxide, acid anhydrides, metal hydrides.
    13. **Controlled Substances -** Narcotics and other controlled substances should be stored in a secure, locked location such as a drawer or safe. See SB Controlled Substances
5. Specific Storage Requirements
    1. Peroxide Formers
        1. In the presence of air and light, certain chemicals, such as ethers, liquid paraffins, and olefins can form peroxides. More specific examples include isopropyl ether, diethyl ether, tetrahydrofuran and dioxane. In some cases, peroxides can be formed even if the containers have not been opened. Therefore, safety precautions should be taken in laboratories working with such chemicals. See SB Peroxides
        2. Chemicals should always be dated.
        3. Unopened containers of ethers should be discarded after one year, unless inhibitors have been added.

However, once these bottles have been opened, they should only be kept for 6 months.

4. Store in a cool, dry and well ventilated location.
5. These chemicals should be kept away from heat, shock, friction and impact.

2. Corrosives
    1. Should be kept in acid resistant cabinets or on polyethylene trays.
    2. Must never be stored on high shelves.
    3. Should be kept away from metal containers and from heat sources, which will result in the decrease of the evaporation rate of these chemicals.
    4. Corrosives shall not be stored under sinks or in other areas where plumbing, equipment, or shelving could be damaged by corrosive effects.
    5. Strong acids (Ph<2) and strong bases (Ph>12.5) shall be stored separately. Where amounts are small, separation can be achieved by either all the acids or all the bases being stored in separate containers such as bottle carriers, spill pans, or other secondary containment.

3. Flammable Liquids
    1. Flammable liquids have flash points below 100 F. Combustible liquids have flash point 100 F.
    2. All secondary containers of flammables greater than 4 liters shall be of the safety can type meeting NFPA standards.
    3. Keep no more than a day's supply of solvent on bench tops, unless in approved safety can.
    4. Storage of more than 25 gallons of flammable liquids shall be in flammable liquid storage cabinets meeting OSHA or NFPA 30 Flammable Liquid Codes.
    5. Flammables shall not be stored in the same cabinet as oxidizers or water-reactive materials.
    6. Only compatible compounds should be stored inside of a cabinet.
    7. Paper, cardboard, or other flammable material should not be stored inside of a flammable-liquid cabinet. Cabinets should not be overloaded. Various sizes of flammable-liquid storage cabinets have different quantity limits determined by the manufacturer
    8. Cabinet doors should be kept closed.
    9. Kent City Fire Department does not require cabinets to be vented.
    10. If these chemicals need to be cooled, they are to be placed in explosion-proof refrigerators only.
        1. **Never store flammable liquids in a standard or domestic refrigerator.**
        2. If flammable liquids must be refrigerated or cooled they must be kept in an approved "flammable storage" refrigerator or freezer. These units are available from many vendors. Domestic refrigerators have a variety of ignition sources inside the cabinet, such as lights, switches, defrost coils, etc. that could ignite vapors. Flammable storage refrigerators have no ignition sources inside the cabinet. In extremely rare occasions it may be necessary to use an "explosion proof" refrigerator or freezer (i.e., one with no interior or exterior ignition sources) in hazardous locations.
        3. Refrigerators used for food storage should be labeled with a "Store No Chemicals" label. Refrigerators used for storage of non-flammable chemicals should be labeled with "Store No Food" label.
        4. Environmental rooms (cold/warm rooms) have many ignition sources and little or no air circulation from outside. They should never be used for storage of flammable or other hazardous materials. Small quantities of hazardous materials (e.g. 500 ml) may be used in these spaces but they should not be stored there.
4. Explosives
    1. Should only be kept in minute quantities and in specially designated areas.

5. Water Reactives
    1. These chemicals should be kept away from exposure to moisture or accidental contact with water.

6. Perchloric Acid (Concentrated, 70%)
    1. Store on glass or ceramic trays that are large enough to hold the volume of the container in case of a spill.
    2. Separate perchloric acid from sulfuric acid, organic material and metals.
    3. Store perchloric acid in a dust-free area.
    4. Perchloric acid should be used only in wash-down fume hoods of non-combustible construction.
    5. Perchloric acid and organic chemicals should never be used in the same fume hood.

7. Highly Toxic, Carcinogenic Or Mutagenic Chemicals
    1. These chemicals should be kept in restricted access with to authorized personnel only

The following tables detail chemical incompatibilities that should be avoided.

Table 1. Strong Oxidizer-Reducer Incompatibilities

(Chemical Safety and Disposal Guide, University of Wisconsin-Madison Safety Department)

When combined, strong oxidizers and reducers can result in a violent reaction. Therefore, contact between these chemicals must be avoided.

OXIDIZERS	**REDUCERS**
Benzoyl peroxide Bromine Chloramides Chlorimides Hydrogen peroxide solutions Metal peroxides (i.e. sodium, barium, zinc) NBS (N-bromosuccinimide) NCS (N-chlorosuccinimide) Osmium tetraoxide **Salts and Solutions of:** Bromates Bromites Chlorates Chlorites Chromates Dichromates Hypochlorites Iodates Manganates Nitrates Nitrites Percarbonates Perchlorates Periodates Permanganates Persulfates Selenates Vanadates	**Group I metals:** Cs, K, Li, Na, Rb and some of these salts **Group II metals:** Be, Mg, Ca powder, and some salts of these metals, including Grignard reagents, Ba and Sr **Transition metals:** Co, Cr, Fe, Mn, Ni, and V carbonyls Al, Fe, Ni, Zn powders **Catalysts:** Pd, Pt, Rh, and Ru **Others:** Alkenes Alkynes Amines Anilines Carbon powder Hydrazine Hydroxylamine Indoles Phenols Pyrroles Mercaptans Phosphines Phosphorous (any color) Hydrides Sulfides Silicone hydrides Sodium dithionite or hydrosulfite **Solid Salts and solution of:** Hypophosphites Phosphites Sulfites Sulfides Thiocyanates

	Thiosulfates Cyanides Sulfur powder

Table 2. Toxic Gas Generation

(Chemical Safety and Disposal Guide, University of Wisconsin-Madison Safety Department)

Toxic gases can be produced when certain chemicals are mixed together, whether in a spill or breakage in a package. The following table represents the production of these gases with respect to the chemicals used to produce them.

COMPOUND	MIXED WITH	PRODUCES
Ammonium Salts	Strong Base	Ammonia
Azide Salts	Strong Acid	Hydrazoic Acid
Bromide Salts	Strong Acid	Hydrogen Bromide
Bromide Salts	Strong Oxidizer	Bromine Vapor
Bromites and Bromates	Strong Acid	Bromine & Bromine Oxides
Chloride Salts	Strong Acid	Hydrogen Chloride
Chloride Salts	Strong Oxidizer	Chlorine Gas
Chlorite or Chlorate Salts	Strong Acid	Chlorine and Chlorine Oxides
Cyanide Salts	Any Acid	Hydrogen Cyanide
Ferrocyanide or Ferrocyanide Salts	Strong Acid	Hydrogen Cyanide
Fluoride Salts	Strong Acid	Hydrogen Fluoride
Hypochlorite Salts	Any Acid	Chlorine
Iodide Salts	Strong Acid	Hydrogen Iodide
Methyl, Nitroso Amides (Diazald)	Any Base	Diazomethane
Nitrite Salts	Strong Acid	Nitric Oxides
Sulfide or Bisulfide Salts	Any Acid	Hydrogen Sulfide
Sulfite or Bisulfite Salts	Any Acid	Sulfur Dioxide

Table 3. Water or Moist Air Incompatibilities

(Chemical Safety and Disposal Guide, University of Wisconsin-Madison Safety Department)

Certain chemicals used in laboratories have the potential to react with water. Therefore such chemicals should not be kept in damp areas or in places where they might accidentally contact water, such as under sinks.

Immediate Violent Reaction with Water
Aluminum chloride, anhydrous
Boron tribromide
Chlorosulfonic acid
Diketene
Fuming sulfuric acid (Oleum)
Magnesium chloride, anhydrous
Methyl fluorosulfonate
Oxalyl chloride
Phosphorus pentachloride
Phosphorus pentoxide
Silicon tetrachloride
Titanium tetrachloride
Triethyl oxonium hexafluorophosphate
Trifluoroacetic anhydride
Trimethyl oxonium hexafluorophosphate
Trifluoromethane sulfonic anhydride

Reaction with Water that Slowly Accelerates to Violence
Acetyl chloride
Alkyl isocyanates
Chloroformate esters
Methane sulfonyl chloride
Phosphorus tribromide
Phosphorus trichloride

Reaction with Water that Slowly Accelerates to Violence
Sulfur mono-, di-, and tetra-chlorides
Sulfur trioxide
Sulfuryl chloride
Thionyl chloride
Thiophosphoryl chloride

Produces Chlorine Spontaneously
Sulfuryl chloride
Phosphorus pentachloride

Produces Chlorine Due to Water Absorption
Calcium hypochlorite

Produces Chlorine Due to Carbon Dioxide Absorption
Calcium hypochlorite
Sodium hypochlorite solution
Methyl ethyl ketone peroxide in dimethyl
Dimethyl phtalate
Hydrogen peroxide solution
Pyruvie acid
Trichloromethyl carbonate

Immediate Violent Reaction with Water & Ignition in Air as a Result of Reaction
Calcium carbide
Group 1A, 2A, 3A alkyls, amides, hydrides and nitrides
Lithium aluminum hydride
(lithium tetrahidridoaluminate)
NaK (sodium-potassium alloy)
Potassium metal
Sodium metal

Absorption of Atmospheric Water Causes Heat &/or Pressure Build-up
Alkyl chloroformates
Calcium chloride, anhydrous
Chloroacetone
Chloroacetaldehyde

Absorption of Atmospheric Water Causes Slow Hydrogen Chloride Release
Arsenic, antimony, and bismuth trichloride
Dichlorodimethyl silane
Silicon, titanium, vanadium, germanium,
And tin tetrachloride, anhydrous
Toluenesulfonyl chloride

Absorption of Atmospheric Water is Continually diluting salt
Antimony trichloride
Ferric perchlorate
Mercuric nitrate
Sodium sulfide, nonanhydrate
Trichloroacetic acid
Zinc Chloride

Self-Pressurizing:
Chloroformate esters
Chromic acid (spent)
Diethyl pyrocarbonate
Formic acid
Methyl formate