Hazardous material storage guide general rules and principles

Stock containers of chemicals in ASU labs must be organized and stored in accordance withthis guidance.

The primary purpose of this guide is to provide hazardous material users guidance regarding how to control health or physical hazards posed by hazardous materialsduring storage in the lab. Specifically, it is designed to:

- Minimize the potential of exposure to poisons.
- Protect flammables from ignition.
- Segregate incompatible materials to prevent their accidental mixing.

A designated storage place for each compound

Stock chemical containers should have a designated storage place and returned to that location after each use. Storage locations can be marked on containers.

Do not store excess supplies of chemicals on lab bench tops where they are unprotected from ignition sources or potentially damaged. Only chemicals in use or of low hazard, e.g., salts and buffers, are permitted on bench tops.

Do not store in chemical fume hood

Do not keep excessive supplies of chemicals or waste in chemical fume hoods where they clutter space, interfere with the hood's air-flow, and contribute to materials that could become involved in a fire or accidental release of hazardous materials.

Close or seal all chemical containers

All chemical containers must be closed except when adding or removing material including bottles used for hazardous waste chemicals. Hazardous waste containers must remain closed except when actually filling the container. In some instances, potential pressure build-up inside of containers poses a significant hazard, written SOPs should warn users about such a hazard and provide alternative guidance.

Alphabetical only within storage groups

Do not store chemicals in alphabetical order except within a storage group. Alphabetical arrangement of randomly collected chemicals often increases the likelihood of dangerous reactions by bringing incompatible materials into close proximity.

Away from sun and heat

Storage areas should not be exposed to extremes of heat or sunlight.

Storage under the sink

Do not store any chemicals except compatible general cleaning agents under the sink. Chemicals can be stored in a cabinet under a fume hood if the cabinet is designed and manufactured for hazardous material storage.

Label chemicals and hazardous waste properly

All containers within the lab must be labeled according to the instructions in the ASU Chemical Hygiene Plan. Suspect and known carcinogens must be labeled as such and segregated within secondary trays to contain leaks and spills. Hazardous waste containers must be labeled with the words “Hazardous Waste” and must include a description of the contents.

Liquid chemicals

Storage of liquid chemicals is more hazardous than storage of solids and are subject to numerous and varied storage requirements.

Safeguard against theft

This plan does not require security measures, e.g., locked cabinets, to prevent theft, but lab workers should make sure that lab doors are locked when unattended.

Chemical storage groups

Chemicals must be stored in the groups and corresponding facilities described on the following pages. This guide demonstrates nine storage groups. Seven of these groups are for storage of liquids because of the variety of hazards posed by these chemicals. Specific instructions must be followed for metal hydrides (Group 8) and certain individual compounds, but otherwise, all dry solids are in Group 9.

How to determine correct storage group

Determine the correct storage group by the hazard information on the chemical container label, chemical Safety Data Sheet, or SDS, or contact ASU EHS.

Multi-hazard liquids

Many liquid chemicals pose hazards that correspond to more than one storage group. Liquid storage groups are shown in descending order of hazard. The correct storage group for a multi-hazard chemical is the group representing the greatest storage hazard, or the group appearing highest in this list.

Group 1: Flammables — **Most Hazardous**

Group 2: Volatile Poisons

Group 3: Oxidizing Acids

Group 4: Organic and Mineral Acids

Group 5: Liquid Bases

Group 6: Liquid Oxidizers

Group 7: Non-Volatile Poisons

Group 8: Metal Hydrides

Group 9: Dry Solids — **Least Hazardous**

Storage group definitions

Group 1: flammable liquids

Includes liquids with flashpoints < 100°F Examples: all alcohols, acetone, acetaldehyde, acetonitrile, amyl acetate, benzene, cyclohexane, dimethyldichlorosilane, dioxane, ether, ethyl acetate, histoclad, hexane, hydrazine, methyl butane, picolene, piperidine, propanol, pyridine, some scintillation liquids, all silanes, tetrahydrofuran, toluene, triethylamine, and xylene

Primary storage concern: To protect from ignition.

Acceptable storage facilities and methods:

- Explosion-proof refrigerator/freezer.
- Flammable cabinet.
- In-use containers such as properly labeled squirt bottles may be on benchtops.

Compatible storage groups: Flammables may be with either Group 2 Volatile Poisons or Group 5 Liquid Bases, but not with both.

Group 2: volatile poisons

Includes poisons, toxics, and "select" and suspected carcinogens with strong odor or anevaporation rate greater than 1 (butyl acetate = 1). Examples: carbon tetrachloride, chloroform, dimethylformamide, dimethyl sulfate, formamide, formaldehyde, halothane, mercaptoethanol, methylene chloride, phenol.

Primary storage concern: To prevent inhalation exposures.

Acceptable storage facilities and methods:

- Flammable cabinet.
- Refrigerator for containers less than 1 liter.

Compatible storage groups: Volatile poisons may be stored with flammables if bases are notpresent.

Group 3: oxidizing acids

All oxidizing acids are highly reactive with most substances and each other. Examples: nitric, sulfuric, perchloric, phosphoric, and chromic acids.

Primary storage concern: Preventing contact and reaction with each other and othersubstances and corrosive action on surfaces.

Acceptable storage facilities and methods:

- Each oxidizing acid must be double-contained. I.e., the primary container must be keptinside a canister, tray or tub.
- Safety cabinet.

Compatible storage groups: Oxidizing acids must be double-contained and should be segregated in their own compartment in a safety cabinet. When quantities are small (e.g., 1 or2 small bottles) they do not warrant a separate compartment. Small quantities may be double-contained and stored with Group 4 Organic and Mineral Acids. Store oxidizing acids on the bottom shelf see section below Group 4.

Group 4: organic and mineral acids

Organic and mineral acids. Examples: acetic, butyric, formic, glacial acetic, hydrochloric, isobutyric, mercaptoproprionic, proprionic, trifluoroacetic acids.

Primary storage concern: To prevent contact and reaction with bases and oxidizing acids andcorrosive action on surfaces.

Acceptable storage facilities and methods:

Safety cabinet.

Compatible storage groups: Small amounts of double-contained oxidizing acids can be stored in the same compartment with organic acids if the oxidizing acids are stored on the bottom shelf.

Exceptions: Acetic anhydride and trichloroacetic anhydride are corrosive. These acids are very reactive with other acids and should not be stored in this group. It is better to store thesewith organic compounds.

Group 5: liquid bases

Liquid bases. Examples: sodium hydroxide, ammonium hydroxide, calcium hydroxide, glutaraldehyde.

Primary storage concern: Preventing contact and reaction with acids.

Acceptable storage facilities and methods:

- In tubs or trays in a standard cabinet.
- Safety cabinet.

Compatible storage groups: Liquid bases may be stored with flammables in the flammablecabinet if volatile poisons are not stored in the same cabinet.

Group 6: liquid oxidizers

Oxidizing liquids react with everything potentially causing explosions or corrosion of surfaces. Examples: ammonium persulfate, hydrogen peroxide – if greater than or equal to 30%.

Primary storage concern: To isolate from other materials.

Acceptable storage facilities and methods:

Total quantities exceeding 3 liters must be kept in a cabinet housing no other chemicals smaller quantities must be double-contained when stored near other chemicals – e.g., ina refrigerator.

Compatible storage groups: None.

Group 7: non-volatile liquid poisons

Includes highly toxic – LD_{50} oral rat < 50 mg/kg – and toxic chemicals, LD_{50} oral rat < 500 mg/kg, "select carcinogens", suspected carcinogens, and mutagens. Examples: acrylamide solutions; Coomassie blue stain; diethylpyrocarbonate; diisopropyl fluorophosphate;uncured epoxy resins; ethidium bromide; triethanolamine

Primary storage concern: To prevent contact and reaction with other substances.

Acceptable storage facilities and methods:

- Cabinet or refrigerator – i.e., must be enclosed.
- Do not store on open shelves in the lab or cold room.
- Liquid poisons in containers larger than 1 liter must be stored below bench level onshelves closest to the floor; smaller containers of liquid poison can be stored abovebench level only if behind sliding – non-swinging – doors.

Compatible storage groups: Non-hazardous liquids – e.g., buffer solutions.

Exceptions: Anhydrides –e.g., acetic and trichloroacetic– are organic acids, however it is betterto store them with this group since they are highly reactive with other acids.

Group 8: metal hydrides

Most metal hydrides react violently with water; some ignite spontaneously in air, or pyrophoric. Examples: sodium borohydride, calcium hydride, lithium aluminum hydride.

Primary storage concern: To prevent contact and reaction with liquids and, in some cases,air.

Acceptable storage facilities and methods:

- Secure, waterproof double-containment according to label instructionsIsolation from other storage groups.

Compatible storage groups: If securely double-contained to prevent contact with water and/orair, metal hydrides may be stored in the same area as Group 9 Dry Solids.

Group 9: dry solids

Includes all powders, hazardous and non-hazardous. Examples: benzidine, cyanogen bromide, ethylmaleimide, oxalic acid, potassium cyanide, sodium cyanide

Primary storage concern: To prevent contact and potential reaction with liquids.

Acceptable storage facilities and methods:

- Cabinets are recommended, but if not available, open shelves are acceptableStore above liquids.
- It is recommended that the most hazardous substances in this group be segregated It is particularly important to keep liquid poisons below cyanide- or sulfide-containing poisons (solids); a spill of aqueous liquid onto cyanide- or sulfide-containing poisons would cause a reaction that would release poisonous gas.
- Warning labels on highly toxic powders should be inspected and highlighted or amendedto stand out against less toxic substances in this group.

Compatible storage groups: Metal hydrides, if properly double-contained may be stored inthe same area.

Exceptions: Solid picric or picric sulfonic acid can be stored with this group, but should be checked regularly for dryness. When completely dry, picric acid is explosive and may detonate upon shock or friction.

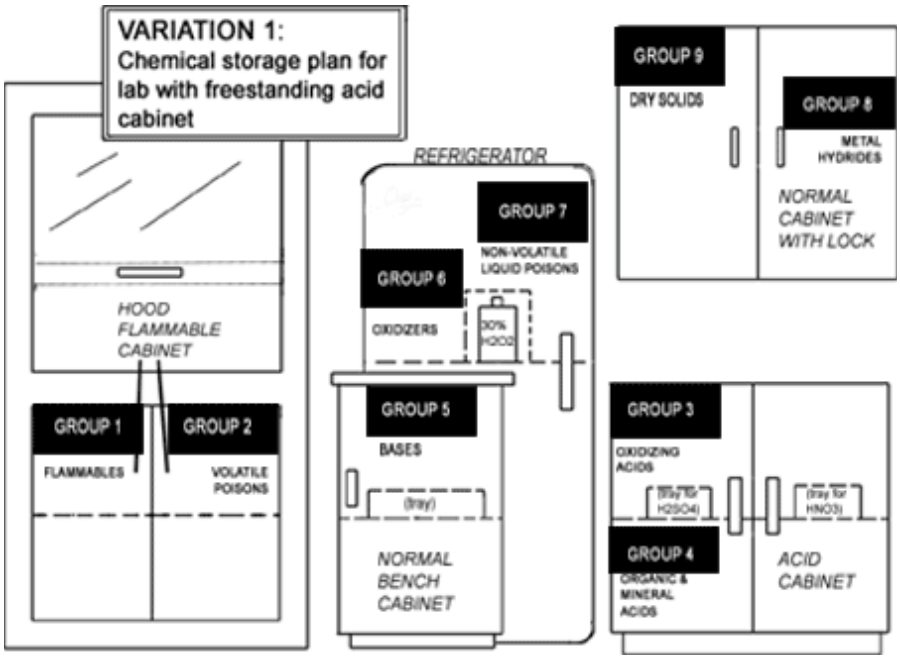
Storage plan variations for different laboratory facilities

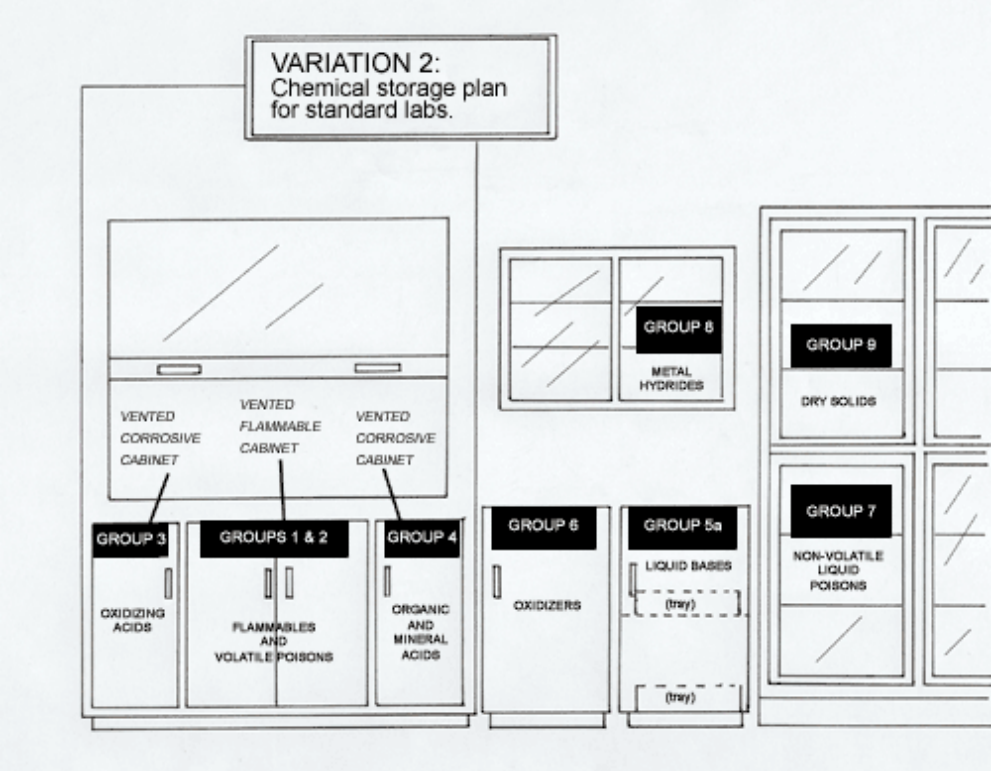
On the following pages are illustrations of possible (non-mandatory) chemical storage arrangements for two types of lab facilities. They are provided merely as examples of arrangements that satisfy the requirements of the chemical storage plan. They are not intendedto restrict storage to the particular arrangements and facilities depicted. Refer to Storage GroupDefinitions for segregation and facility requirements.

The illustrations are titled as follows:

Variation 1: Chemical storage plan for lab with freestanding acid cabinet.

Variation 2: Chemical storage plan for standard labs.





Examples of incompatible chemicals

The following is not a complete listing of incompatible materials. It contains some of the more common incompatible materials. Always utilize research materials such as Safety Data Sheetsyou work with in order to work safely in the lab.

Chemicals listed in Column A should not be stored with or used near those in Column B.

Column A	Column B
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates.
Acetic anhydride	Hydroxyl-containing compounds such as ethylene glycol, perchloric acid.
Acetone	Concentrated nitric and sulfuric acid mixtures, hydrogen peroxide.
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury.

Alkali and alkaline earth metals such as powdered magnesium, sodium, potassium	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens.
Ammonia (anhydrous)	Mercury, halogens, calcium hypochlorite, hydrofluoric acid.
Column A	**Column B**
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials.
Aniline	Nitric acid, hydrogen peroxide.
Arsenical materials	Any reducing agent.
Azides	Acids, heavy metals and their salts, oxidizing agents.
Calcium oxide	Water.
Carbon, activated	All oxidizing agents, calcium hypochlorite.
Carbon tetrachloride	Sodium.
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible material.
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide.
Chromic acid and chromium trioxide	Acetic acid, alcohol, camphor, glycerol, naphthalene, flammable liquids in general.
Copper	Acetylene, hydrogen peroxide.
Cumene hydroperoxide	Acids (organic or inorganic).
Cyanides	Acids.
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens, other oxidizing agents.
Fluorine	All other chemicals.
Hydrides	Water.
Hydrocarbons (e.g., butane,	Fluorine, chlorine, bromine, chromic acid, peroxides.

propane, benzene)	
Hydrocyanic acid	Nitric acid, alkalis.
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous).
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, any flammable liquid (i.e., alcohols, acetone), combustible materials, aniline, nitromethane.
Column A	**Column B**
Hydrogen sulfide	Fuming nitric acid, oxidizing gases.
Hypochlorites	Acids, activated carbon.
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen.
Mercury	Acetylene, fulminic acid, ammonia.
Metal hydrides	Acids, water.
Nitrates	Acids.
Nitric acid (concentrated)	Acetic acid, acetone, alcohol, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals.
Nitrites	Acids.
Nitroparaffins	Inorganic bases, amines.
Oxalic acid	Mercury and silver and their salts.
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases.
Perchloric acid	Acetic anhydride, alcohol, bismuth, paper, wood, grease, oils.
Permanganates	Concentrated sulfuric acid, glycerol, ethylene glycol, benzaldehyde.
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold.
Phosphorus, white	Air, oxygen, alkalis, reducing agents.
Potassium	Carbon tetrachloride, carbon dioxide, water.

Potassium chlorate	Sulfuric and other acids, ammonium salts, metal powders, sulfur, finely divided organics, combustibles.
Potassium perchlorate (see also chlorates)	Sulfuric and other acids.
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid.
Silver and silver salts	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid.
Column A	**Column B**
Sodium	Carbon tetrachloride, carbon dioxide, other chlorinated hydrocarbons, water.
Sodium nitrate	Ammonium nitrate and other ammonium salts.
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural.
Sulfides	Acids.
Sulfuric acid	Chlorates, perchlorates, permanganates.

Adapted from *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*,National Research Council, 1995

Basic chemical segregation

Hazard class of chemical	Recommended storage method	Examples	Incompatibilities
Compressed gases - Flammable	Store in a cool, dry area, away from oxidizing gases. Securely strap or chain cylinders to a wall or bench.	Methane Hydrogen Acetylene Propane	Oxidizing and toxic compressed gases, oxidizing solids.
Compressed gases - Oxidizing	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench.	Oxygen Chlorine Bromine	Flammable gases.
Compressed gases - Poisonous	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench.	Carbon monoxide Hydrogen sulfide Nitrogen dioxide	Flammable and/or oxidizing gases.
Hazard class of chemical	**Recommended storage method**	**Examples**	**Incompatibilities**
Corrosives - Acids	Store separately in acid storage cabinet. Segregate oxidizing acids (i.e., Chromic, nitric, sulfuric, and perchloric acids) from organic acids.	Acetic acid Phenol Sulfuric acid Chromerge Nitric acid Perchloric acid Chromic acid Hydrochloric acid	Flammable liquids, flammable solids, bases, oxidizers.
Corrosives - Bases	Store in separate corrosive storage cabinet. Store solutions of inorganic hydroxides in labeled polyethylene containers.	Ammonium hydroxide Sodium hydroxide Calcium hydroxide	Flammable liquids, oxidizers, poisons, and acids.

Flammable Liquids	Store in flammable storage cabinet and away from sources of ignition. Store highly volatile flammable liquids in an explosion-proof refrigerator.	Acetone Benzene Diethyl ether Methanol Ethanol Toluene Glacial acetic acid	Acids, bases, oxidizers, and poisons.
Flammable Solids	Store in a separate dry, cool area away from oxidizers, corrosives, flammable liquids	Phosphorus, yellow Calcium carbide Picric acid Benzoyl peroxide	Acids, bases, oxidizers, and poisons.
General Chemicals - Non-reactive	Store on general laboratory benches or shelving preferably behind glass doors and below eye level.	Agar Sodium chloride Sodium bicarbonate Most non-reactive salts	See specific MSDS.
Water-Reactive Chemicals	Store in dry, cool location, protect from water fire sprinkler.	Sodium metal Potassium metal Lithium metal Lithium aluminum hydride	Separate from all aqueous solutions and oxidizers.
Hazard class of chemical	**Recommended storage method**	**Examples**	**Incompatibilities**
Oxidizers	Store in a spill tray inside a chemical storage cabinet. Separate from flammable and combustible materials.	Ammonium persulfate Ferric chloride Iodine Sodium hypochlorite Benzoyl peroxide Potassium permanganate Potassium dichromate The following are generally considered oxidizing substances:	Separate from reducing agents, flammables, and combustibles.

		Peroxides, perchlorates, chlorates, nitrates, bromates, and superoxides.	
Poisons/Toxic Compounds	Store separately in vented, cool, dry area, in unbreakable chemically-resistant secondary containers and in accordance with the hazardous nature of the chemical.	Aniline Carbon tetrachloride Chloroform Cyanides Heavy metals compounds, i.e., cadmium, mercury, osmium Oxalic acid Phenol Formic acid	Flammable liquids, acids, bases, and oxidizers. See specific MSDS.
Carcinogens	Label all containers as "Cancer Suspect Agents". Store according to the hazardous nature of the chemical, using appropriate security when necessary.	Benzidine Beta-naphthylamine Benzene Methylene chloride Beta-propiolactone	See specific MSDS.
Hazard class of chemical	**Recommended storage method**	**Examples**	**Incompatibilities**
Teratogens	Label all containers as "Suspect Reproductive Hazard". Store according to the hazardous nature of the chemical, using appropriate security when necessary.	Lead and mercury compounds Benzene Aniline	See specific MSDS.

Peroxide-Forming Chemicals	Store in air-tight containers in a dark, cool, dry area. See Table 3 for recommended storage time limits.	Diethyl ether Acetaldehyde Acrylonitrile	See specific MSDS.
Strong Reducing Agents	Store in cool, dry, well-ventilated location. Water reactive. Segregate from all other chemicals.	Acetyl chloride Thionyl chloride Maleic anhydride Ferrous sulfide	See specific MSDS.

Suggested storage time limits for common peroxide crystal forming compounds

Peroxide formation occurs when certain laboratory chemicals react with air at ordinary temperatures to form peroxy compounds, which are violently reactive or explosive. Organic peroxides are classified as low-power explosives that are hazardous because ofthe sensitivity to shock, sparks or other ignition sources. Additionally, they are sensitive to heat, friction, impact, light and strong oxidizing and reducing agents.

All organic peroxides are flammable and have a specific rate of decomposition under agiven set of conditions. Due to unusual stability problems, bulk quantities of peroxidesshould be approached with caution because they may generate enough heat to auto accelerate up to ignition. Peroxides and Peroxide forming chemicals include, but are not limited to the following lists.

Most dangerous: Discard after 3 months. Peroxide formation hazard during storage.	
Diisopropyl ether	Potassium metal
Divinyl acetylene	Sodium amide
Isopropyl ether	Vinylidene chloride

Dangerous: Discard after one year. Peroxide formation hazard during storage and on concentration, i.e., distillation, of compound.		
Acetal	Dicyclopentadiene	Methyl cyclopentane
Acetaldehyde	Diethyl ether	Methyl isobutyl ketone
Cumene	1,4-Dioxane	Tetrahydrofuran
Cyclohexene	Ethylene glycol dimethyl ether	Tetrahydronaphthalene
Diacetylene	Methyl acetylene	Vinyl ethers

Dangerous: Discard after one year. Peroxide formation causes initiation of hazardous polymerization.		
Acrylic acid Acrylonitrile 1,3-Butadiene 2-Butanol	Chloroprene ChlorotrifluoroethyleneMethyl methacrylate 2-Propanol Styrene	Tetrafluoroethylene Vinyl acetate Vinyl acetylene Vinyl chloride Vinyl pyridine

Contact ASU Environmental Health and Safety
at 480-965-1823 or email asuehs@asu.edu.

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