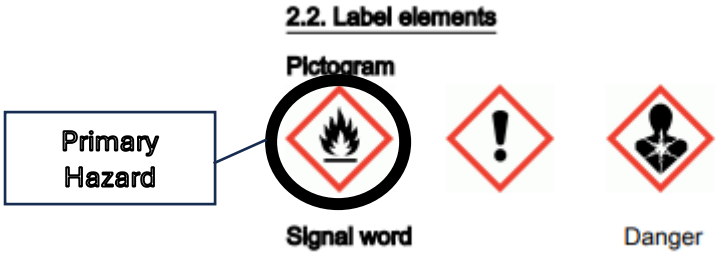
Guidance on Safe Storage of Chemicals in the Laboratory

1. Introduction

The typical research and teaching laboratories are the home to various chemicals requiring safe storage. The following information intends to offer guidance on the basic principles of safe chemical storage in laboratories. However, the guidance is not meant to be exhaustive, and risk assessors must check specific Material Safety Data Sheets (MSDS) for more detailed information.

2. Basic Principles of Chemical Storage

- All chemicals should be stored based on hazard type, with primary hazards being prioritized. The primary hazard is identified by the first pictogram found in section 2.2 of the MSDS. The example below shows the primary hazard as 'flammable'.



- Store like materials with like. It is essential to segregate incompatible substances to prevent dangerous interactions. All hazardous chemicals should be labelled to identify their hazard category (e.g., flammable, corrosive, oxidising, toxic etc.)
- Store the minimum stock levels of hazardous chemicals in the laboratory.
- Dispose of hazardous chemicals that are no longer required immediately.
- Store all containers, particularly of liquids, below shoulder height.
- Ensure containers and bottle tops are sealed properly to avoid unnecessary leakage of fumes / vapours.
- Never carry a bottle containing chemicals by its top, for example always carry Winchester bottles (2.5 litres) in carriers or baskets that can provide proper support, and support the base of the bottle in use.

Please note that fume cupboards are not designed or intended for the storage of chemicals. The working surfaces of fume cupboards should therefore be kept clear of materials and containers when these are not needed for the ongoing work activities. Excess storage of chemicals in fume cupboards disrupts the airflow resulting in a lower level of protection for users.

Flammable solvents should also not be stored in fume hoods, as the airflow will fan any fire and may also spread the fire to other parts of the building via the ventilation ducting.

3. Storage of specific chemicals

3.1 Flammable Solvents - e.g., alcohols, toluene, hexane

The vapour from flammable liquids is very susceptible to ignition by naked flames, sparks from electric switches (e.g., thermostats) electric motors or from sparks produced electrostatically by friction. Precautions must therefore be taken to prevent contact between any of these and the flammable liquids.

Flammable solvents should be stored in specialised metal flammable solvent containers/ cabinets, clearly labelled and positioned away from doors or other means of escape from the laboratory.
Flammable Solvent Cabinets are made of fire-resistant material with a minimum fire resistance of 30 minutes as required by British Standard 476. A metal spill tray is used to contain spillages.

No more than 50 litres of flammable material may be kept in any one laboratory room to reduce the risk of a serious laboratory fire. Working volumes of flammable solvents (i.e., those kept on the bench) should not exceed 500 ml (this volume can be easily contained should an accident/fire occur) and the solvent must be kept in a suitable closed vessel.

Flammable solvents must never be stored in a refrigerator unless it is known to be spark-proof. It is strongly advised that all laboratory fridges are spark-proofed to avoid the possibility of an internal light or thermostat control unit providing a source of ignition for vapours produced from flammable substances.

Flammable solvents must never be stored with:

- **Oxidizing agents** such as chlorates, nitrates, perchlorates, permanganates and peroxides.
- **Corrosive chemicals** (acids or bases that destructively attack organic and non-organic material). Common acids include sulphuric acid, acetic acid, and nitric acid. Common alkalis (bases) include ammonium hydroxide, calcium oxide, and sodium hydroxide.
- **Materials susceptible to spontaneous heating and/or explosions**. Hydrogen peroxide contacting combustible material can result in spontaneous combustion. Picric acid can be explosive if dry (sensitive to shock and friction when dry)
- **Substances that react with air or moisture to create heat**. Concentrated sulphuric acid is a corrosive that can react violently with water, giving off heat and an irritating toxic fume.

The MSDS should always be consulted if further information is required on storage and chemical incompatibilities of a particular chemical substance.

3.2 Chlorinated solvents (e.g., chloroform, dichloromethane (DCM) trichloroethylene)

Chlorinated solvents are best stored separately from flammable (non-chlorinated) solvents because violent reactions can result from the mixing of certain flammable and chlorinated solvents. - toxic gases such as phosgene (as well as hydrogen chloride and chlorine) can be produced.

They should not be stored with alkali metals such as lithium, potassium or sodium, since any mixing can cause an explosion.

A dedicated ventilated storage unit would be ideal.

3.3 Corrosive substances

They must be stored separately, as any accidental mixing of concentrated materials will generate large quantities of heat and fumes. Corrosive acids and bases must be stored separately for the same reason.

They can be sorted in a vented or metal cabinet or another laboratory cabinet, provided they are appropriately labelled and have a containment tray to capture any spillages.

Specific acid cabinets are available. These are made of acid resistant materials and should contain a tray, to contain any leakage or spillage.

Consideration must be given to the effects of corrosive fumes on any metal in the fittings and construction of the container.

The use of ventilated cabinets is recommended where possible, allowing the removal of fumes at source.

All containers / bottle tops must be suitably sealed to avoid unnecessary leakage of corrosive fumes.

If any discoloration of the lid or container is noted, the substance has damaged the container and is leaking hazardous fumes. The substance must be disposed of.

Ventilated Cabinets – usually positioned beneath a fume cupboard and attached to its duct – are desirable for storing acids as they ensure any corrosive vapours are removed immediately.

3.4 Oxidisers (e.g., peroxides, perchlorates and nitrates)

Oxidising substances should be stored in a metal cabinet and away from organic matter such as wood and paper (NB oxidising agents should never be sorted in a wooden cabinet!).

Oxidising agents must never be stored with flammable solvents or reducing agents since fires and explosions can result after any spillage, even without a naked flame or heat.

Perchloric acid is an extremely strong oxidising agent (especially in the concentrated form), which can react explosively with organic materials. It should ideally be stored separately on a metal tray within a cabinet, away from organic materials or dehydrating agents such as sulphuric acid.

Consult the MSDS for length of storage.

3.5 Toxic substances

It is good laboratory practice to store all dangerous substances labelled **toxic/highly toxic** (includes substances that are also **carcinogenic/mutagenic/toxic** to reproduction) in a locked cupboard, considering practicalities of access and local security.

In addition, it is recommended that certain alkaloids and their derivatives, e.g., aconitine, brucine, ecgonine and atropine, which do not appear on the Poisons List, and digitoxin, digitonin, valinomycin and actinomycin D, are also kept locked away.

Very toxic chemicals, i.e., those which have Lethal Dose Values LD 50 (30 days) of less than 10mg/kg, should be locked away at the end of each working day and be tightly managed / controlled.

Certain hazardous chemicals require particular treatment with regard to storage, use and disposal due to being covered by additional regulations (on top of COSHH).

4. Controlled Chemicals Legislation

Controlled chemicals are those subjected to additional legislation from COSHH, which may require the department to hold a license before work can begin.

4.1 Chemical Weapons Convention

Chemical weapons and their precursors are categorized into three schedules. If we obtain these chemicals from commercial suppliers for lawful research, we must submit an annual report to UK Chemical weapons Convention CWC/ DECC detailing our use, storage, and production of Schedule 2 and 3 substances. The University does not have a licence for the use of Schedule 1 substances.

4.2 Who is responsible for submitting the declaration to DECC on behalf of the University?

The Safety Department is responsible for carrying out this task. Please contact the Health and Safety Team if you are planning on purchasing controlled substances.

4.2 Implications for researchers/end users

"If you use Chemical Weapon substances, you are considered the 'consumer'. You must:

1. Maintain a local record of the amount of the substance(s) you have used throughout the year – only you can keep track of this. If other researchers in the department are using the same stock bottle, someone will need to take responsibility for monitoring usage."
2. Report any unexpected or unexplained loss to the correct authority.

4.5 Storage of Controlled Substances

All chemicals on the list of controlled substances must be stored under lock and key. These include:

1. Controlled Drugs List
2. Misuse of Drugs Act Schedule 2
3. Chemical Weapons Convention Schedule 1, 2 and 3
4. Drug Precursors Category 1
5. Schedule 5 pathogens and toxins

5. Old/Legacy chemicals

There can be hazardous and non-hazardous issues with old chemicals.

- Plastic containers will eventually go brittle and may crack/shatter and lead to container failure and exposure. There have been a few incidents with old nitric acid bottles.
- Some chemicals form peroxides with air over time e.g., diethyl ether can form explosive peroxides in a matter of months. As a shock-sensitive explosive, it can be very dangerous if there is the presence of crystalline solid in the remaining liquid or it has dried out completely. Peroxide testing strips can be purchased and are an inexpensive way of testing a solvent's viability before any visible crystals have been formed.

- Another high hazard legacy chemical is explosives which are desensitised with water. The most common being picric acid.
- Organic chemicals will decompose leaving them less effective for research, quantitative analysis and use in standard solutions.

To avoid old / legacy chemicals from building up, disposal arrangements for any substances no longer required will be checked as part of the Horizon Exit Journey.

The appropriateness of storage arrangements will also be sampled as part of local workplace inspections.
(See also https://www.gre.ac.uk/about%20us/governance/safety/policy/arr/inspections

References

- *Safety in academic chemistry laboratories*, The American Chemical Society
- *Challenges for Health and Safety in Higher Education and Research Organisations*.
- Chemical Weapons Convention guidance - GOV.UK (www.gov.uk)

Appendix: Incompatibility table of Common Laboratory Chemicals

The improper storage or mixing of chemicals / substances can result in violent reactions leading to serious accidents and even disasters. Before storing or mixing any chemicals, consult this list or the relevant MSDS. This is only a partial list that includes some of the more common academic laboratory chemicals. Please note that the absence of a chemical from the list does not mean that it is necessarily safe to mix it with any other chemical! You should always check with the MSDS if in doubt.

Chemical / Substance	Incompatible with
Acetic Acid	Inorganic acids, oxidizing agents, ethylene glycol, hydroxyl compounds (bases)
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Acetone	Concentrated nitric acid and sulphuric acid mixtures, oxidizing agents, bleach
Alkali & Alkaline Earth Metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia *(Anhydrous)*	Mercury (e.g., in manometers), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium Nitrate	Acids, powered metals, flammable liquids, chlorates, nitrites, sulphur, finely divided organic combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenical Materials	Any reducing agent
Azides	Acids, metals
Bromine	See chlorine
Calcium Oxide	Water
Carbon *(Activated)*	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, acids, powered metals, sulphur, finely divided organic or combustible materials
Chromic Acid and Chromium Trioxide	Acetic acid, naphthalene, camphor, glycerol. Alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine
Chlorine Dioxide	Ammonia, methane, phosphine, hydrogen sulphide
Copper	Acetylene, hydrogen peroxide
Cumene Hydroperoxide	Acids (organic and inorganic)
Cyanides	Acids [including very weak acids] Oxidising agents, metallic salts, any substance with a pH below 7
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens

Chemical / Substance	Incompatible with
Fluorine	All other chemicals
Hydrocarbons *(Butane, Propane, Benzene Etc.)*	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic Acid	Nitric acid, alkali
Hydrofluoric Acid	All bases (aqueous or anhydrous)
Hydrogen Sulphide	Fuming nitric acid, oxidizing agents
Hypochlorites	Acids, activated carbon, flammable liquids
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Acids
Nitric Acid *(Concentrated)*	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulphide, flammable liquids and gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic Acid	Silver, mercury
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, and gases
Perchloric Acid	Acetic acid, anhydride, bismuth and its alloys, alcohols, flammables, paper, wood, grease, oils
Peroxides, Organic	Acids (organic or mineral), flammables, avoid friction, store cold
Phosphorus *(White)*	Air, oxygen, alkalis, reducing agents
Potassium Chlorate	Sulphuric and other acids, flammables
Potassium Perchlorate *(See Also Chlorates)*	Sulphuric and other acids, flammables
Potassium Permanganate	Glycerol, ethylene glycol, benzaldehyde, sulphuric acid, flammables
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium Nitrite	Ammonium nitrate and other ammonium salts
Sodium Peroxide	Ethyl and methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulphides	Acids
Sulphuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metal, such as sodium, lithium)
Tellurides	Reducing agents