STANDARD OPERATING PROCEDURES (SOP) FOR SAFETY IN CHEMISTRY LABORATORIES FOR RESEARCH AND TEACHING

INTRODUCTION

Chemical laboratories in universities, also handle many hazardous chemicals though in smaller quantities. From academic point of view, chemicals are broadly classified into organic chemicals and inorganic chemicals. As for as chemical safety is concerned chemicals are classified based their dominant hazardous properties. The widely accepted classification is given below:

1. Flammable chemicals
2. Health hazard causing chemicals (Toxic chemicals)
3. Oxidizing agents
4. Explosive chemicals
5. Water-sensitive chemicals
6. Gases under pressure

Many of these chemicals can be hazardous to health, environment; also can cause fires as well as explosions. The chemicals may be simple irritants, asphyxiants, poison, or they may affect a particular organ in the body. They may affect body metabolism or the entire nervous system. These effects are summarized below:

Respiratory Irritants: Gases like ammonia, sulfur dioxide, formaldehyde. Chloride, bromine, etc. cause local irritation of the upper respiratory tract and. If inhaled more deeply, also of the lower respiratory tract and the lungs. They may also cause irritation of the mucous membranes of eye, nose and throat. Oxides of nitrogen and phosgene can cause serious effect in fairly high concentrations.

Chemical Asphyxiants: Gases like CO_2, N_2, H_2, are simple asphyxiants and cause dilution of oxygen concentration. Other asphyxiants deprive the body cells of oxygen. For example, hemoglobin of the blood has a preferential affinity towards CO (about 300 time greater than for oxygen), hence, when carbon monoxide is inhaled high amounts, the blood fails to carry enough oxygen to the tissues.

H_2S: Produces respiratory paralysis.

HCN: Protoplasmic poison; prevents oxygenation of the body cells.

Anesthetics and Narcotics: The anesthetic and narcotic act as simple anesthesia without serious systematic effects, and has a depressant action on the central nervous system governed by their partial pressure in the blood-supply to the brain.

The ill effects on health and hazards of fire and explosion can be controlled by a careful study of the hazardous properties of the chemicals. Identifying chemical hazard is the first step towards chemical safety. The useful source that gives details on hazardous properties and safety to be adopted is the Material Safety Data Sheet (MSDS). By following proper control measures and understanding in detail the consequences of violating safety rules and procedures the occurrences of the incidents in the chemical labs of the Universities can be avoided or minimized. The ***Standard Operating Procedure*** **(SOP)** for safety in chemistry laboratories discusses what should be do be done and what should not be done while handling chemicals under various headings. Hence, the following measures in storing, usage and disposal of chemicals and responding to emergency shall be strictly adhered.

1. General Guidelines

- Rigorously follow safety rules and procedures at all times.
- Know storage, handling, and disposal requirement for each chemical used.
- File Material Safety Data Sheet (MSDS) for each chemical that you use.
- Consult MSDS and guidelines of University for disposal information and always follow appropriate chemical disposal regulations
- All student, staffs and faculty members should be wearing the appropriate personal protective equipment (i.e. chemical splash goggles, laboratory aprons or coates, and gloves).
- Never work alone in the laboratory and never allow unauthorized visitors to enter the laboratory.
- No chemical should be taken out of laboratory without authorization.
- Smoking, eating food, and drinking beverages are not permitted inside the labpratory.

2. Storage of Chemicals

- Make sure all chemicals and reagents are labeled properly.
- Make inventory of all chemicals that you purchase.
- Enter the name of the chemicals regularly in inventory.
- Store acids in a dedicated acid cabinet. Nitric acid should be stored alone unless the cabinet provides separate compartment for nitric acid storage.
- Store highly toxic chemicals in a dedicated, lockable poison cabinet that has been labeled with a highly visible sign.
- Store volatile and odoriferous chemicals in a ventilated cabinet.
- Store water sensitive chemicals in water-tight cabinet in a cool and dry location segregated from all other chemicals in the laboratory. Potassium and sodium metal and metal hydrides are examples; hydrogen is produced with sufficient heat to ignite with explosive violence.
- Do not place heavy materials, liquid chemicals, and large containers on high shelves.
- Do not store chemicals on the tops of cabinets.

- Do not store chemicals on the floor, even temporarily.
- Do not store items on bench tops and in laboratory chemical hoods, except when in use.
- Do not store chemicals on shelves above eye level
- Do not store chemicals with food and drink.
- Do not store chemical in personal staff refrigerator, even temporarily.
- Do not expose stored chemical to direct heat or sunlight, or highly variable temperatures.

3. Usage and Handling of Chemicals

- ✓ Add concentrated acid to water slowly. Never add water to a concentrated acid.
- ✓ Chemicals like picric acid and many peroxides are sensitive to shock or impact. These chemical on exposure to shock, impact or heat may release sudden energy in the form of heat or an explosion. Spilling should not be allowed. Such chemicals should be guarded against rough handling.
- ✓ Use hot water bath to heat flammable liquids. Never heat directly with flame.
- ✓ Use laboratory fume hood, when there is a possibility of release of toxic chemical vapors, dust, or gases.
- ✓ When using a fume hood, the sash opening should be kept at a minimum to protect the user and to ensure efficient operation of the hood. Keep your head and body outside of the fume hood face.
- ✓ Chemical and equipment should be placed at least six inches within the hood to ensure proper air flow.
- ✓ When transporting chemicals (especially 250 mL and or more), place the immediate container in a secondary container or bucket (rubber, metal or plastic) designed to be carried and large enough to hold the entire contents of the chemical.

4. Disposal Protocols and Procedures

4.1 Don’t mix any solvent, chemical as it will be costly for the disposal

4.2 Don’t mix solid waste, liquid waste, sharps, gloves, capillaries, slides, columns, tips, tubes, broken glassware, plastic ware, etc. keep them in covers, label and place them in card board box and deposit for disposal.

4.3 Use solvent supplied empty container for storage of used solvent that need to be disposed.

4.4 store used silica gel, alumina and matrixes etc. in the empty container/polythene covered card board box of the same material

4.5 Store used chemicals and reagents in the same container.

4.6 If you have obtained any mixed chemicals from your experiment, record its composition (chemicals used) and store in separate empty bottles.

4.7 Please note that material safety data sheets for each and every materials need to be provided as per environmental ministry guidelines

4.8 Materials appropriate for sewer disposal in limited quantities must meet the following criteria:

- They are liquids and readily water soluble (at least 3%)
- Easily biodegradable or amenable to treatment by the waste water treatment process
- Simple salt solutions of low toxicity inorganic substances
- The chemical that have a pH between 5.5 and 9.5

4.9 Chemicals that can be safely disposed of down the drain include biological compounds and cellular constituents such as proteins, nucleic acids, carbohydrates, sugars, amino acids amines, surfactants and many metabolic intermediates.

4.10 Other compounds include soluble salt combinations of low toxicity ions and **dilute (less then 10%)** aqueous solutions of low molecular weight biodegradable organic chemicals such as alcohols, aldehydes, ketones, amines, ethers, cellosolves, nitriles, esters and nitroalkanes.

Examples of materials in these categories include:

Cations: Aluminum (Al), Ammonium (NH^{4+}), Calcium (Ca^{2+}), Cesium (Cs^{+}), Hydrogen (H^{+}), Lithium (Li^{+}), Magnesium (Mg^{2+}),Potassium (K^{+}), Sodium (Na^{+}), Strontium (Sr^{2+}), Tin (Sn^{2+})

Anions: Bicarbonate (HCO^{3-}), Bisulfite (HSO^{3-}),Bromate (BrO^{3-}), Bromide (Br^{-}), Carbonate (CO_3^{2-}), Chlorate (ClO_3^{-}), Chloride (Cl^{-}), Hydroxide (HO^{-}),Iodate (IO_3^{-}), Iodide (I^{-}), Nitrate (PO_4^{3-}), Nitrite (NO_2^{-}), Oxide (O_2^{-}), Phosphate (PO_4^{3-}), Sulfate (SO_4^{2-}), Sulfite (SO_3+).

Note that before discharging into sewer makes sure that all other criteria (such as pH, flammability, toxicity, etc. limits) are met. If you are not sure, please collect these chemicals in respective empty container (without mixing) and deposit hazardous waste management facility.

4.11 **Dilute (<5%) aqueous solutions** of low molecular weight biodegradable organic chemicals appropriate for sanitary sewer discharge include:

Alcohols: Alkanols with fewer than 5 atoms, Alkanediols with fewer than 8 atoms, S ugars and sugar alcohols, Alkoxyalk anols with fewer than 7 carbon atoms, butanols, [1-(*n*- butyl alcohol, 2- (sec- butyl alcohol)], ethanol [2- (2-butoxyethoxy)], ethylene glycol, glycerol, methyl 1-propanol, 2- (isobutyl alcohol), methyl 2- butanol, 2- (t-amyl alcohol), methyl 2-propanol, 2- (tert - butyl alcohol), propanol, 1- (n - propyl alcohol), propanol, 2- (isopropyl alcohol),

Amides: $RCONH_2$ and RCONHR with fewer than 5 carbon atoms, $RCONR_2$ with fewer than 11 carbon atoms, formamide, propionamide, methylpropionamide, N-butanamide

Amines: Aliphatic amines with fewer than 7 carbon atoms, Aliphatic diamines with fewer than 7 carbon atoms, benzylamine, butylamine, N-

Aldehydes: Aliphatic aldehydes with fewer than 5 carbon atoms, butyraldehyde, gluteraldehyde

propionaldehyde

Carboxylic Acids: Alkanoic acids with fewer than 6 carbon atoms, Alkanedioic acids with fewer than 6 carbon atoms, Hydroxyalkanoic acids with fewer than 6 carbon atoms, Aminoalkanoic acids with fewer than 7 carbon atoms, Ammonium, Sodium, and Potassium salts of the

above acid classes with fewer than 21 carbon atoms, acetic acid, citric acid, oxalic acid, potassium binoxalate, propanoic acid, sodium acetate, sodium citrate

Esters: Esters with fewer than 5 carbon atoms, isopropyl acetate, methyl acetate, methyl formate, methyl propionate, propyl formate, n-

Ethers: dioxolane

Ketones: Ketones with fewer than 6 carbon atoms, pentanone, 2-

Nitriles: propionitrile

Sulfonic Acids: Sodium or potassium salts of most are acceptable

Note that before discharging any of these materials into sewer make sure that all other criteria such as pH limits and flammability) are met.

4.12 When discharging waste to the sanitary sewer, you should:

- Never dispose of anything that might lead to a storm sewer rather than a sanitary sewer.
- Use a sink that does not have a history of clogging or overflowing.
- Use a sink in your laboratory, preferably in a hood.
- Flush with at least 10-20 fold excess of water after drain disposal to thoroughly rinse out the sink and sink trap, and to dilute the waste.
- Limit the quantities being discharged to 100 grams of solute per laboratory per day.
- Wear gloves, eye protection and a laboratory coat.

4.13 **The following materials should <u>NEVER</u> be disposed of through the sanitary sewer system.**

- Any waste chemical that meets the EPA's criteria for being hazardous, either as a listed or characteristic waste.
- Oil, grease, or other water insoluble chemicals
- Materials that are not biodegradable or would pass through the sewage treatment plant into the New
- Haven harbor and be toxic to aquatic organisms or accumulate in harbor sediments.
- Flammable and combustible solvents (flashpoints less than 140 °F) (unless sufficiently diluted in
- water as part of the laboratory process such that the solution has a flashpoint greater than 140oF)
- Discharges with a pH below 5.5 or higher than 9.5
- Materials that could interfere with the biological processes of sewage treatment or would contaminate
- The sludge-making disposal through the normal methods difficult or impossible.

- All compounds that could result in the presence of toxic gases or vapors within the POTW in a
- quantity that may cause acute worker health and safety problems
- Malodorous compounds or volatile organic chemicals that can escape from the plumbing system (such as dry traps) causing exposures or obnoxious odors (such as mercaptans or thiols).
- Metallic ions and salts of the heavy metals in solutions or suspension in concentrations exceeding the following:

Element	Concentration (Mg/l)
Arsenic	0.05 (WPCA)
Barium	5.0 (WPCA)
Boron	5.0 (WPCA)
Cadmium	0.1 (WPCA)
Chromium	1.0 (WPCA)
Copper	1.0 (WPCA)
Cyanide	0.1 (WPCA)
Lead	0.1 (WPCA)
Manganese	1.0 (WPCA)
Mercury	0.01 (WPCA)
Nickel	1.0 (WPCA)
Selenium	0.02 (WPCA)
Silver	0.1 (WPCA)
Zinc	1.0 (WPCA)

- Pesticides in solutions or suspension in concentrations exceeding the following:

Element	Concentration (Mg/l)
Chlordane	0.3 (EPA)
2,4-D	10.0 (EPA)
Endrin	0.02 (EPA)
Heptachlor (and its epoxide)	0.008 (EPA)
Lindane	0.4 (EPA)
Methoxychlor	10.0 (EPA)
2,4,5-TP (Silvex)	1.0 (EPA)

- Organic compounds in solutions or suspension in concentrations exceeding the following:

Element	Concentration (Mg/l)
Benzene	0.5 (EPA)
Carbon tetrachloride	0.5 (EPA)
Chlorobenzene	100 (EPA)
Chloroform	100 (EPA)
Cresol (or total of o-, m- and p-Cresol)	200 (EPA)
1,4-Dichlorobenzene	7.5 (EPA)
1,2-Dichloroethane	0.5 (EPA)
1,1-Dichloroethylene	0.7 (EPA)
2,4-Dinitrotoluene	0.13 (EPA)
Hexachlorobenzene	0.013 (EPA)
Hexachlorobutadiene	0.5 (EPA)
Hexachloroethane	3.0 (EPA)
Methyl ethyl ketone	200 (EPA)
Nitrobenzene	2.0 (EPA)
Pentachlorophenol	100 (EPA)
Pyridine	5.0 (EPA)
Tetrachloroethylene	0.7 (EPA)
Toxaphene	0.5 (EPA)
Trichloroethylene	0.5 (EPA)
2,4,5-Trichlorophenol	400 (EPA)
2,4,6-Trichlorophenol	2.0 (EPA)
Vinyl chloride	0.2 (EPA)

4.14 Other than above chemicals, may have to be separately worked out based on material safety datasheet.

4.15 All empty cans, bottles etc. of Non-sewage disposal category should be used collection of waste of respective material.

4.16 Other bottles should be kept in a card board box and deposited in waste disposal allocated at respective schools or call help from UPE office at 4040 in one day advance.

4.17 All bottles filled solvent or chemical waste should be placed in card board box and prepare an inventory, enclose material safety data sheets and handover to HWM personnel of UPE office.

4.18 If you have mixed waste, provide composition and process in which it is produced for assessing appropriate treatment strategy by agency. Please do not mix waste produced two different processes.