Highly Reactive & Potentially Explosive Chemicals

Introduction

Several chemicals present in laboratories become highly reactive or explosive when exposed to certain environmental conditions (e.g., heat, fire, water, air, etc.). Others become explosive when they contact incompatible materials, are allowed to dry out, decompose or encounter sources of friction or mechanical shock. Due to the high hazards associated with such compounds, appropriate procedures, control measures, personal protective equipment and training are imperative to ensure safe use. Failure to comply with safety measures can lead to explosions, fires, property damage, serious injuries or even death.

Classes of Highly Reactive or Explosive Chemicals

The Occupational Safety & Health Administration (OSHA) classifies many chemicals as highly reactive or potentially explosive. A table of the hazard classes, pictograms, descriptions and examples of each class is listed below.

Hazard Class	Pictogram	Definition	Examples
Explosives		An ***explosive chemical*** is a solid or liquid chemical which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.	*Benzoyl peroxide* *Dinitrophenol* *Lead azide* *Nitroglycerin* *Nitrocellulose* *Picric acid*
Chemicals which, in contact with water, emit flammable gases		***Chemicals which, in contact with water, emit flammable gases*** are solid or liquid chemicals which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.	*Alkali metals* *Calcium carbide* *Metal alkyls* *Grignard reagents* *Sodium hydride* *Zinc powders*

Hazard Class	Pictogram	Definition	Examples
Organic peroxides	 or 	***Organic peroxide*** means a liquid or solid organic chemical which contains the bivalent -0-0- structure and as such is considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals.	*Acetaldehyde* *Diethyl ether* *Isopropyl ether* *Potassium metal* *Tetrahydrofuran*
Pyrophoric liquids		***Pyrophoric liquid*** means a liquid which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.	*t-Butyllithium* *Diethylzinc* *Grignard reagents* *Tributylphosphine* *Trimethyl aluminum*
Pyrophoric solids		***Pyrophoric solid*** means a solid which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.	*Alkali metals* *Finely divided metals* *Metal hydrides* *White Phosphorus*
Self-Heating		A ***self-heating chemical*** is a solid or liquid chemical, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is liable to self-heat; this chemical differs from a pyrophoric liquid or solid in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days).	*Carbon, activated* *Potassium sulphide, anhydrous* *Thiourea dioxide* *Titanium disulphide*
Self-Reactives	 or 	***Self-reactive chemicals*** are thermally unstable liquid or solid chemicals liable to undergo a strongly exothermic decomposition even without participation of oxygen (air).	*2,2'-Azobisisobutyronitrile* *Azodicarbonamide*

Safe Work Practices

Due to the inherent risks involved with the use of highly reactive or explosive chemicals, measures should be taken to assess risk and control hazards prior to engaging in active experimentation. Conducting "dry runs" of high hazard experiments using less hazardous chemicals is recommended to reinforce proper techniques, safety measures and emergency procedures. The guidelines listed below should be followed when handling high hazard chemicals.

Administrative Controls

- Safety training should be provided by the principal investigator or other qualified personnel to all researchers working with highly reactive or potentially explosive chemicals. Documented training is recommended.
- Read the safety data sheet (SDS) for each chemical prior to use.
- Eliminate or substitute less hazardous chemicals if possible.
- Use the minimum amount of chemical(s) needed to achieve the desired outcome.
- Avoid working alone with highly reactive or explosive chemicals.
- **NEVER** deviate from standard operating procedures unless previously discussed and agreed upon with the principal investigator or other qualified supervisor.
- Alert other laboratory personnel on what experiment is being conducted, what the potential hazards are, and when the experiment will be run.
- Restrict access to areas where high-scale reactions are taking place.

Work Practice Controls

- All containers holding potentially explosive materials must be clearly labelled.
- Do not use metal or wooden devices when stirring, cutting, scraping, etc. with potentially explosive compounds. Non-sparking plastic devices should be used instead.

- Ensure safety devices such as high temperature controls, water overflow devices, etc., are used in combination to help minimize any potential incidents.
- Chemicals known to become explosive when dry should be regularly inspected and wetted if necessary (e.g. picric acid).
- Chemicals that are known to become explosive after a period of time (e.g. peroxide-forming chemicals) should be labeled with the date the bottle was delivered to the lab, the date the bottle was first opened, and disposed of before the expiration date.
- Keep all sources of ignition away from reactive or explosive materials.
- When highly reactive materials are in use, emergency equipment, specific for the hazards involved, should be readily available.

Engineering Controls

- Most work involving high hazard or explosive chemicals should be performed in a fume hood, glove box, or with other forms of ventilation.
- Fume hood sashes only provides a safety shield against chemical splashes, fires, and minor explosions. In some cases, acrylic sliding shields may need to be installed in hoods or glove boxes to help protect workers from glass fragments resulting from laboratory-scale explosions.
- Properly-rated safety shields, barricades, and guards may be necessary to protect personnel and equipment from injury or damage. The barrier should surround the entire hazardous area.
- If more than one hazardous reaction is carried out simultaneously, the reactions should be shielded from each other and separated as far apart as possible.
- Adequate grounding is essential to prevent static sparks from acting as ignition sources.
- Armored laboratory chemical hoods or barricades made with thick (1.0 in.) poly (vinyl butyral) resin shielding and heavy metal walls may be necessary for work with some explosive chemicals.

Personal Protective Equipment

- Wear personal protective equipment as indicated in **safety data sheets (SDSs)** or the lab's workplace hazard assessment form.
- At a minimum, chemical splash goggles should be worn by all lab personnel. When researchers are exposed to highly hazardous chemicals during active experiments, full-length shields that protect the entire face and throat are recommended.
- Heavy leather or other suitable gloves should be worn if researchers must reach behind a shielded area while a hazardous experiment is in progress or when handling high hazard chemicals.
- Flame-resistant lab coats should be worn at all times. The coat should be able to be removed quickly during an emergency.
- Closed toed footwear that covers the entire foot should be worn at all times.
- Additional personal protective equipment may be necessary based on the chemicals in use and the risks involved.

Storage

- Store in a designated storage area or cabinet with limited access.
- Additional storage precautions (i.e., a refrigerator, a flammable liquid storage cabinet, a fume hood) may be required for certain compounds based upon chemical properties.
- Store away from incompatible materials.
- Keep away from ignition sources such as open flames, hot surfaces, spark sources, and direct sunlight.
- Storage in chemically-compatible secondary containers is recommended to contain highly reactive chemicals in the event of a leak or spill.
- Never store unlabeled chemicals.

Additional Resources

Occupational Safety & Health Administration- Chemical Reactivity Hazards

http://www.osha.gov/SLTC/reactivechemicals/index.html

Occupational Safety & Health Administration- Physical Hazard Criteria

http://www.osha.gov/dsg/hazcom/hazcom-appendix-b.html

Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards

http://www.ehs.uconn.edu/Chemical/Prudent%20Practices%20in%20the%20Laboratory.pdf