

# CHEMICAL HYGIENE PLAN

## (SECTION II)

<b>UCSB Policies, Procedures and Resources</b>	<b>3</b>
<b>Emergency Response</b>	
Chemical Spill Procedures / Spill Kit Locations	<b>6</b>
Fire Extinguishers	<b>8</b>
First Aid Resources	<b>9</b>
Emergency Showers and Eye Washes	<b>10</b>
Exposure Limits for Laboratory Chemicals	<b>11</b>
<b>General Chemical Safety Information</b>	
What is a Materials Safety Data Sheet (MSDS)?	<b>13</b>
Use of Particularly Hazardous Substances	<b>14</b>
Safe Storage of Chemicals	<b>14</b>
Refrigerators and Freezers in the Laboratory	<b>17</b>
Carcinogen Control	<b>18</b>
Chlorinated Solvents	<b>19</b>
Non-Halogenated Solvents	<b>20</b>
Flammable Materials	<b>22</b>
Corrosives (Acids and Bases)	<b>23</b>
Distillations and Extractions	<b>24</b>
SOP for the Use of Pyrophoric/Water Reactive Reagents	<b>28</b>
SOP for the use of Hydrofluoric Acid	<b>41</b>
SOP for the Use of Strong Oxidizers	<b>43</b>
SOP for the Use of Picric Acid	<b>45</b>
SOP for the Use of Perchloric Acid	<b>47</b>
SOP for the Use and Generation of Azide Ion and Organic Azides	<b>48</b>
SOP for the Use of Hydrogen Cyanide and Cyanide Salts	<b>50</b>
<b>Physical Hazards</b>	
Compressed Gas Cylinders	<b>50</b>
Cryogenics	<b>54</b>
Vacuum Systems	<b>55</b>

## UCSB Department of Chemistry and Biochemistry

High Pressure Reaction Vessels	57
Seismic Hazard Reduction	59
<b>Personal Protection</b>	
Campus Policy on Personal Protective Equipment (PPE)	60
PPE in UCSB Storerooms	62
Selecting the Proper Gloves	63
Respirators	63
<b>Fume Hood Usage Guide</b>	
Standard Hoods	65
Variable Air Volume (VAV) Hoods	66
<b>Waste Disposal</b>	
Biological/Medical Waste Disposal	67
Chemical Waste Disposal	69
Sharps and Glass Disposal	71

## UCSB POLICIES, PROCEDURES, AND RESOURCES

### INTRODUCTION

Section II addresses the campus policies, procedures and resources which are universal and apply to all/most labs. In order to free lab supervisors from independently having to address these issues in their CHPs, they are provided herein. In Section I of this document the *laboratory-specific* portion of a lab's Chemical Hygiene Plan should be addressed.

**The issues summarized here are a formal part of the *UCSB Chemical Hygiene Plan*. Therefore, all lab personnel are responsible for being familiar with this information and following the prescriptions therein as they apply to their work.**

### ONLINE RESOURCES

An important aspect of the Cal-OSHA CHP safety standard is that it addresses *chemical* safety issues, but not other laboratory hazards: For example, biological and radiological hazards, electricity, high/low temperature and pressure, etc. Therefore, these issues are largely not addressed here. However, additional laboratory safety information on these topics can be found on the EH&S website under the "Lab Safety & Chem Hygiene" tab:

**<http://www.ehs.ucsb.edu>**

The UCSB Environmental Health and Safety website contains substantial information concerning workplace safety. The information can be broken down into the following broad categories:

1. **General education materials** on basic lab health and safety, e.g. good practices for use of flammables, electrical safety etc...
2. **Specific campus resources** available to the lab community, e.g. training classes, MSDS, self-inspection checklists, etc...
3. **Specific campus policies and procedures**, e.g. waste disposal, emergency response, etc...

*CAMPUS POLICY ON LABORATORY SAFETY TRAINING*

Documentation of occupationally-related safety training is a legal requirement under Cal-OSHA. Accordingly, as of July 2010, UCSB instituted a policy regarding baseline safety training of all “laboratory workers”. In short, the policy requires that all lab workers attend one of the EH&S general lab safety orientations as outlined below before being issued access to their lab. Note that the trainings described below are generic and do not address the specific hazards, procedures and practices for a particular laboratory, or individual. Lab supervisors/Pis are still responsible under the law for ensuring this has been provided.

All members of the campus lab community have responsibilities under the policy - particularly the individual's home department which is responsible for ensuring new lab workers are identified and guided into the appropriate training session. The full policy can be found at:

<http://www.policy.ucsb.edu/policies/policy-docs/lab-safety-training.pdf>

**Summary of Required Training**

1. **Required for Graduate Students:** A 3-hour instructor-led general laboratory safety orientation is offered regularly - generally twice per quarter. This training is more in-depth than those listed below and generally includes hands-on fire extinguisher training. This training is open to any laboratory worker and all are encouraged to take this course.
2. **Required for Postdoctoral Scholars:** A Web-based “postdoc” video, handouts and quiz package are available through EH&S. Alternatively, a PI/supervisor may, at their discretion, choose to send a postdoctoral scholar to the more in-depth instructor-led course above.
3. **Required for Undergraduate Students Working in Research Laboratories:** A Web-based “undergraduate” video, handouts and quiz package are available through EH&S. Alternatively, a PI/supervisor may, at their discretion, choose to send a postdoctoral scholar to the more in-depth instructor-led course above.
4. **Required for Laboratory Staff and Laboratory-working Visitors:** One of the training sessions described above, as determined by the supervisor. The more in-depth instructor-led orientation is recommended whenever feasible.

**NON-UCSB RESOURCES FOR ONLINE SAFETY TRAINING**

Documented safety training is a legal requirement of the California Occupational Safety and Health Administration (Cal-OSHA) and ideally also helps prevent accidents. Within the UC system are a number of online safety training modules as listed below - the link below will lead to the trainings. However, as someone accessing these modules from outside that campus the training will not be documented. It is therefore recommended that the supervisor have the training documented at the time of completion.

**Link to UC (Non-UCSB) Online Laboratory Safety Training:**  
<http://ehs.ucsb.edu/training/lsvideo1.html>

**UC Online Training Catalog:**

*(campuses may have their own version/title for the same subject matter)*

- Carcinogen Handling Safety
- Centrifugation Hazards
- Chemical Storage
- Compressed Gas & Cryogen Safety
- Day in the Life of the Lab (A Pls Perspective)
- Earthquake Safety
- Pressure Safety
- Cryogenics Safety
- Electrical Safety
- Ergonomics for the Laboratory
- Fire Safety in the Laboratory
- Fire Extinguishers Usage
- Formaldehyde Safety
- Fume Hoods
- Hazardous Materials Spill Response
- Hazardous Materials Shipping
- Material Safety Data Sheets
- Nanomaterials Handling
- Practicing Safe Science
- Pyrophoric Reagents Safety



# EMERGENCY RESPONSE

## CHEMICAL SPILL CLEANUP PROCEDURES

The primary informational tool for response to campus incidents is the *UCSB Emergency Information Flipchart* pictured below. This document should already be posted in, or near, every laboratory, as well as in many offices. If you want a copy for your work area, contact EH&S at x-4899. A Spanish language version of the flipchart is also available.

The last page (at right) should be customized to include your *local* building information –such as the locations of the following: your building’s Emergency Assembly Point, fire extinguishers and fire alarm pull stations, first-aid kits, AEDs, etc. If it is not customized contact your local Department Safety Rep. The flipchart can also be viewed online at:

[http://www.ehs.ucsb.edu/homepage/hprsc/203655\\_Emerg\\_Flipchart.pdf](http://www.ehs.ucsb.edu/homepage/hprsc/203655_Emerg_Flipchart.pdf)

**EMERGENCY**

**911**  
9-911  
805-893-3446  
888-488-UCSB (888-488-8272)  
888-SB-ROADS (888-727-6237)  
800-427-ROAD (800-427-7623)  
211 (800-400-1572)  
1610 AM (Within 3 miles of UCSB)  
91.9 FM (KCSB)  
www.ucsb.edu

**Emergency**  
Emergency Campus Telephones  
UCSB Police Dispatch (From cell phones)  
Campus Emergency Information (Toll Free)

**Santa Barbara Road Conditions** (Toll Free)  
**California Road Conditions** (Toll Free)

**SB County Health & Human Services** (From cell phones)  
**Parking/Emergency Information**

**Campus Radio Station**  
UCSB Campus Web Site

**UCSB**  
Environmental Health & Safety 2008

**EMERGENCY MANAGEMENT AT UCSB**

**CIVIL DISTURBANCE OR DEMONSTRATION**

**EXPOSURE TO BLOOD OR OTHER POTENTIALLY INFECTIOUS MATERIALS**

**SHELTER-IN-PLACE**

**MEDICAL EMERGENCY**

**SEVERE WEATHER**

**FIRE**

**SUSPICIOUS PACKAGE/MAIL**

**RADIOACTIVE CONTAMINATION/SPILLS**

**CHEMICAL INCIDENTS**

**VIOLENCE/CRIME IN PROGRESS/ACTIVE SHOOTER**

**EARTHQUAKE / TSUNAMI**

**EVACUATION OF CAMPUS/BUILDINGS/PERSONS WITH DISABILITIES**

**BOMB THREATS**

**UTILITY FAILURE / POWER OUTAGES IN LABORATORIES**

**BUILDING-SPECIFIC EMERGENCY INFORMATION**

**BUILDING-SPECIFIC EMERGENCY INFORMATION**

A copy of this completed document should be posted on departmental safety bulletin boards along with a building floor plan.

Building Name: \_\_\_\_\_ Building Number: \_\_\_\_\_  
Building Exit Routes (Note the general locations of exits, e.g., exit stairwell is located on the north side): \_\_\_\_\_

**EXIT**

**Building Emergency Assembly Point**  
(View <http://ehs.ucsb.edu/eap> for the most recent list of the Emergency Assembly Points)

Primary Location: \_\_\_\_\_ Secondary Location: \_\_\_\_\_

Paste Photo Here (optional) \_\_\_\_\_ Paste Photo Here (optional) \_\_\_\_\_

**Fire extinguishers and fire alarm pull station**

Extinguishers are generally located at the **ends of exit hallways** and/or exit doors. Inside labs, they are located **near the exit door**.

Pull stations are generally located at regular hallway intervals and at the ends of exit hallways.

**Type of fire alarm signal for the building**  
(Check all that apply. If in doubt, contact the EH&S Fire Safety Division.)

Bells  Horns/Strobes  Strobe Flashes

Department Safety Rep: \_\_\_\_\_ Phone: \_\_\_\_\_  
Alternate Department Safety Rep: \_\_\_\_\_ Phone: \_\_\_\_\_

**Building Resources**

Location of First Aid Kit(s): \_\_\_\_\_  
(Departmental and/or local work areas)

Location of Automated External Defibrillator (AED), if available: \_\_\_\_\_  
(Device to restore normal heart rhythm to patients in cardiac arrest)

Location of other Emergency Resources (e.g., food, water, radios, flashlights, spill cleanup supplies, etc.) \_\_\_\_\_

For more information on emergency preparedness and fire prevention visit Environmental Health & Safety online <http://ehs.ucsb.edu>.  
Date Prepared: \_\_\_\_\_ (An electronic version is on the EH&S Web site at <http://ehs.ucsb.edu>.)

**BUILDING-SPECIFIC EMERGENCY INFORMATION**

You should NOT clean up a spill if:

- You don't know what the spilled material is

## UCSB Department of Chemistry and Biochemistry

- You lack the necessary protection or equipment to do the job safely
- The spill is too large to contain
- The spilled material is highly toxic
- You feel any symptoms of exposure

Instead contact one of the following:

- **x3194** EH&S (24 hr line – after-hours may have to wait up to 30 min for response to campus)
- Call **9-911** if the spill is immediately health threatening

### Spill Response

#### *Evaluate and Notify*

- Assess the toxicity, flammability, or other properties of the material (see label and MSDS).
- For flammables, remove or turn off all ignition sources such as motors, pumps and refrigerators.
- Determine if there is an immediate health threat to you or your neighbors. If so, alert neighbors, isolate the area and call for help using the numbers listed above.
- If spill is minor, begin cleanup steps below

#### *Containment/Cleanup*

- Spill kit closets are located in PSB-N in 3651 and 2651.
- Wear gloves, eye protection, lab coat etc...
- Contain and absorb spill using absorbents appropriate for material.
- Protect floors and drains from contamination by putting absorbents or barriers around them.
- Package and label wastes. Include contaminated clothes, rags, equipment etc...
- Store waste temporarily in a fume hood if waste is volatile.

#### *Following a spill*

- Send Hazardous Materials/ Waste Pickup Request form to EH&S
- Reorder and restock cleanup materials used
- Inform EH&S if there were any personnel exposures or release to the drain system.

## EMERGENCY RESPONSE

### FIRE EXTINGUISHERS

**Fire Extinguishers:** EH&S conducts hands-on fire extinguisher training for most individuals who attend the EH&S General Laboratory Safety class. There is also an online extinguisher tutorial/video that individuals can complete and receive credit. All campus individuals are strongly encouraged to complete this tutorial and view as refresher training when needed.

**Online Fire Extinguisher Usage Tutorial:**  
<http://learningcenter.ucsb.edu/default.aspx>

Labs are equipped with one, or both of two types of extinguishers: **Carbon dioxide (BC) and Dry Chemical Powder (ABC)**. Carbon dioxide extinguishers are distinguished by their flared hoses, versus a dry chemical extinguisher with a straight hose. Also, dry chemical extinguishers have a pressure gauge while carbon dioxide extinguishers do not. **In the corridors of the Chemistry and Physical Sciences North building there are yellow Class D extinguishers for fighting metal fires such as sodium or magnesium.**

All uses of fire extinguishers must be promptly reported to County Fire (9-911) even if the fire is extinguished. EH&S (x-3194) should also be notified so the extinguisher can be recharged. Note, once activated an extinguisher will slowly leak the propellant rendering the device useless in a future emergency.

#### Types of Fires

**Class A:** Ordinary combustibles such as wood, paper, cloth, rubber and many plastics

*Proper extinguishers*

- Dry Chemical
- Pressurized Water (corridor hoses)

**Class B:** Flammable or combustible liquids

*Proper extinguishers*

- Dry Chemical
- Carbon dioxide

**Class C:** Energized electrical equipment. Cut the power source. Do not use water on such fires until the power has been removed from the area

*Proper extinguishers*

- Dry Chemical
- Carbon dioxide

**Class D:** Combustible Metals. Do not use ordinary extinguishers or water for these fires

*Proper extinguisher*

- Class D extinguishers labeled "FOR METAL FIRES ONLY"



## **EMERGENCY RESPONSE**

### *FIRST AID RESOURCES*

**In the event of an emergency or life threatening situation, contact emergency response at:**

**9-911**

#### **First Aid Kits**

Each PI is responsible for maintaining a first aid kit for their laboratories. This kit should be clearly marked and all laboratory personnel informed of its location and contents.

#### **Defibrillator (AED)**

A portable automatic external defibrillator (AED) is located in the graduate student mailroom, 1512 PSB-N. This room is located just outside of the machine shop entrance.

### **In the event of a coronary emergency call 9-911**

Training in first aid, cardiopulmonary resuscitation (CPR) and use of the AED is offered periodically by the American Red Cross and by the campus EH&S office. See the web links below for more information and class schedules.

#### **Santa Barbara Chapter of the American Red Cross**

<http://www.sbaco-redcross.org>

#### **UCSB Environmental Health and Safety**

<http://www.ehs.ucsb.edu/>

## EMERGENCY RESPONSE

### *EMERGENCY SHOWERS AND EYE WASHES*

- Know where your nearest unit is – they are typically within the lab, or in the corridor nearby. Units must be accessible at all times - no items should be blocking access.
- In the case of chemical exposure to eyes or skin, flush the injury for a minimum of 15 minutes. Be sure to leave the eyes open under the water stream to flush them.
- Showers can also be used to extinguish a fire on an individual, or their clothing
- Consult the MSDS for the material and show it to the doctor/nurse.
- Facilities staff periodically flush emergency eyewash stations and showers. Lab personnel should also flush and check the eyewashes at least monthly as a precautionary measure. Call Facilities at x2661 if you have concerns regarding a specific unit.
- Eyewashes are plumbed with potable water - unlike the rest of the laboratory which is often on "industrial water"- and is considered safe to use on your body.
- Many campus eyewash/shower units are not equipped with a floor drain. This is because they are so infrequently used that they did not justify the cost of a drain when the building was constructed. Also, it is illegal to flush hazardous materials down the drain.

**GENERAL CHEMICAL SAFETY INFORMATION***EXPOSURE LIMITS FOR LABORATORY CHEMICALS*

Below are airborne chemical concentration limits above which you cannot legally be exposed at work. These limits are administered by the California Occupational Safety and Health Administration (Cal-OSHA). The materials listed here are a fraction of the total number (500+) of OSHA exposure limits – for the complete list, see: [http://www.dir.ca.gov/Title8/5155table\\_ac1.html](http://www.dir.ca.gov/Title8/5155table_ac1.html) If workers have reason to believe they might be exposed above these limits, or to other hazardous materials, contact EH&S, x-4899, or x-8243. All workers should strive to maintain their chemical exposures to as low as reasonably achievable at all times, regardless of the legal exposure limits. Given the volatility of these materials, they should always be used in a properly functioning fume hood, or glove box, or in completely-sealed systems. The “S” notation indicates material is also readily skin absorbed.

Chemical Abstracts Registry Number <sup>(a)</sup>	Skin <sup>(b)</sup>	Name	Permissible Exposure Limit <sup>(d)</sup>			Short-term Exposure Limit <sup>(e)</sup>	
			ppm <sup>(e)</sup>	mg/M <sup>3(f)</sup>	Ceiling Limit <sup>(g)</sup>	ppm <sup>(e)</sup>	mg/M <sup>3(f)</sup>
64197		Acetic acid	10	25	40 ppm	15	37
67641		Acetone	500	1200	3000 ppm	750	1780
75058	S	Acetonitrile	40	70		60	105
79061	S	Acrylamide	--	0.03			
7664417		Ammonia	25	18		35	27
62533	S	Aniline	2	7.6			
7440371		Argon	(h)				
		Arsenic and inorganic arsenic compounds	--	0.01			
71432	S	Benzene	1			5	--
7726956		Bromine	0.1	0.7	C		
7440439		Cadmium metal dust, as Cd		0.005			
630080		Carbon monoxide	25	29	200 ppm		
7782505		Chlorine	0.5	1.5		1	3
67663		Chloroform; trichloromethane	2	9.78			
110827		Cyclohexane	300	1,050			
287923		Cyclopentane	600	1,720			
75343		1,1-Dichloroethane	100	400			
68122	S	Dimethylformamide; DMF	10	30			
74840		Ethane	(h)				
141786		Ethyl acetate	400	1,400			
64175		Ethyl alcohol; ethanol	1,000	1,900			
74851		Ethylene	(h)				
60297		Ethyl ether	400	1,200		500	1500
50000		Formaldehyde	0.75	--		2	--
75127	S	Formamide	10	18			
64186		Formic acid	5	9		10	19
7440597		Helium	(h)				
142825		n-Heptane	400	1,600		500	2000
110543	S	n-Hexane	50	180			
1333740		Hydrogen	(h)				

## UCSB Department of Chemistry and Biochemistry

10035106		Hydrogen bromide	3	10	C		
7647010		Hydrogen chloride; muriatic acid	5	7	C		
7664393		Hydrogen fluoride, as F	3	2.5		6	--
7722841		Hydrogen peroxide, as H <sub>2</sub> O <sub>2</sub>	1	1.4			
7783064		Hydrogen sulfide	10	14	50 ppm	15	21
26675467		Isoflurane	2	15			
67630		Isopropyl alcohol	400	980		500	1225
7439976	S	Mercury, metallic and inorganic compounds as Hg	--	0.025	0.1 mg/M <sup>3</sup>		
67561	S	Methyl alcohol; methanol	200	260	1000 ppm	250	325
75092		Methylene chloride; dichloromethane	25	87		125	435
7697372		Nitric acid	2	5		4	10
10102439		Nitric oxide	25	30			
7727379		Nitrogen	(h)				
75525		Nitromethane	2	5			
1321126,	S	Nitrotoluene	2	11			
111659		Octane	300	1,450		375	1800
8012951		Oil (mineral) mist, particulate		5			
20816120		Osmium tetroxide, as Os	0.0002	0.002		0.0006	0.006
10028156		Ozone	0.1	0.2		0.3	0.6
109660		Pentane	600	1,800			
127184		Perchloroethylene	25	170	300 ppm	100	685
108952	S	Phenol	5	19			
7664382		Phosphoric acid	--	1		--	3
1310583		Potassium hydroxide; caustic potash	--	2	C		
110861		Pyridine	5	15			
61790532		Silica, amorphous, total dust	-	6			
61790532		Silica, crystalline; quartz total dust	-	0.3			
1310732		Sodium hydroxide; caustic soda	--	2	C		
7664939		Sulfuric acid	--	1		--	3
109999		Tetrahydrofuran	200	590		250	735
108883	S	Toluene; toluol	50	188	500 ppm	150	560
76039		Trichloroacetic acid	1	5			
1330207		Xylene; xylol; dimethylbenzene	100	435	300 ppm	150	655

**Footnotes to Table.** Footnotes have been edited for clarity. For the complete Cal-OSHA Table and complete footnotes, see: [http://www.dir.ca.gov/Title8/5155table\\_ac1.html](http://www.dir.ca.gov/Title8/5155table_ac1.html) (a) The Chemical Abstracts Service Registry Number is a designation used to identify a specific compound or substance regardless of the naming system; (b) The substances designated by "S" in the skin notation column indicates material may be absorbed into the bloodstream through the skin, the mucous membranes and/or the eye, and contribute to the overall exposure. Appropriate protective clothing shall be provided for and used by employees as necessary; (d) Permissible Exposure Limit (PEL) = the maximum permitted 8-hour time-weighted average concentration of an airborne contaminant; (e) Parts of gas or vapor per million parts of air by volume at 25°C and 760mm Hg pressure; (f) Milligrams of substance per cubic meter of air at 25°C and 760mm Hg pressure; (g) Ceiling Limit = the maximum concentration of an airborne contaminant to which an employee may be exposed at any time. A numerical entry in this column represents a ceiling value in addition to the PEL values. A "C" notation means the value given in the PEL columns are also ceiling values; (h) A number of gases and vapors, when present in high concentrations, act primarily as asphyxiants without other adverse effects. A concentration limit is not included for each material because the limiting factor is the available oxygen. (Several of these materials present fire or explosion hazards.); (o) Short-Term Exposure Limit = a 15-minute time-weighted average airborne exposure which is not to be exceeded at any time during a workday even if the 8-hour time-weighted average is below the PEL.

## GENERAL CHEMICAL SAFETY INFORMATION

### *MATERIAL SAFETY DATA SHEETS (MSDS)*

#### **What is a MSDS?**

Material Safety Data Sheets are a summary of the health hazards of a chemical material and associated recommended safe work practices. MSDS are required by OSHA to be made readily available by chemical manufacturers to the purchasers of their chemicals.

If you work in a lab, then OSHA says you should:

- be aware of what an MSDS is and their relevance to your health and safety
- be aware of how to access MSDS for your work area
- maintain any MSDSs that are received with incoming chemical shipments and ensure that they are readily accessible to lab employees during each work shift when they are in their work area(s). Electronic access per below is acceptable with a printer.

#### **MSDS Sources**

[University of California-MSDS Database](#)

[Laboratory Chemical Safety Summaries](#) (not MSDS, but quality info aimed at lab environment)

[Fisher Scientific MSDS](#)

[Vermont Safety Information Resources, Inc. \(SIRI\)](#)

[Sigma-Aldrich MSDS](#)

[MSDS Provider \(Manufacturer-direct access\)](#)

[Matheson's Gases](#)

[Oxford University MSDS Database](#)

[Where to Find MSDSs on the Internet](#)

[Canadian MSDS for Micro-Organisms](#)

#### **Another Information Resource**

The book entitled: [\*Prudent Practices in the Laboratory\*](#) by the National Research Council is widely considered to be a definitive reference. It can be purchased, but is also available free on-line in a searchable format. It is strongly recommended that all lab workers have ready access to this important reference.

## GENERAL CHEMICAL SAFETY INFORMATION

### *USE OF PARTICULARLY HAZARDOUS SUBSTANCES*

Particularly Hazardous Substances (PHS) are defined by Cal-OSHA for the purposes of the Chemical Hygiene Plan law as: human reproductive toxins, known human carcinogens and highly toxic chemicals. In Sec. I of this document (Lab-specific Chemical Hygiene Plan) the proper/safe use of PHS must be addressed by a supervisor as it relates to that lab's policies/procedures. Web links to lists of PHS are provided when the Word version of Sec. I is downloaded to your desktop, or directly at:

<http://ehs.ucsb.edu/units/labsfty/labrsc/chemistry/lischphazsubstance.htm>

## GENERAL CHEMICAL SAFETY INFORMATION

### SAFE STORAGE OF CHEMICALS

**INTRODUCTION:** If incompatible chemicals are inadvertently mixed a fire, explosion, or toxic release can easily occur. In earthquake-prone areas like UCSB, it is particularly vital that chemicals be stored safely. Below are some basic guidelines.

Note however, that chemicals can often fall into more than one hazard category and therefore the chemical label and/or Material Data Safety Sheet should be reviewed for specific storage requirements. Separate chemicals by adequate distance, or preferably by using physical barriers (e.g. storage cabinets). Avoid using the fume hood for chemical storage - this practice may interfere with the proper air flow of the hood. For especially dangerous materials, use a secondary container (e.g. plastic tub) large enough to contain a spill of the largest container.

With the wide variety of chemicals used in laboratories, the list below is prioritized for materials that are **COMMONLY** used in a research laboratory. This chart indicates the most obvious chemical incompatibilities, and provides a basic segregation plan. For more specific chemical incompatibility information, please consult the manufacturer's MSDS, available at <http://ehs.ucsb.edu>, or contact EH&S at x-4899.

#### **ACIDS**

Examples: Acetic Acid; Chromic Acid\*; Hydrochloric Acid; Hydrofluoric Acid; Nitric Acid\*; Perchloric Acid\*; Phosphoric Acid; Sulfuric Acid (\* Indicates strong oxidizing acids, store per oxidizers section)

##### Storage Precautions:

- Store bottles on low shelf areas, or in acid cabinets.
- Segregate oxidizing acids from organic acids, **AND** flammable materials.
- Segregate acids from bases, **AND** from active metals such as sodium, potassium, etc.
- Segregate from chemicals which could generate toxic gases, e.g. NaCN, iron sulfide

#### **BASES**

Examples: Ammonium Hydroxide; Potassium Hydroxide; Sodium Hydroxide

##### Storage Precautions:

- Separate bases from acids.
- Store bottles on low shelf areas, or in acid cabinets.

#### **FLAMMABLES**-fuels are reducing agents

Examples: Acetone, Benzene, Cyclohexane, Ethanol, Ethyl Acetate, Ethyl Ether, Gasoline, Hexane, Isopropyl Alcohol, Methanol, Propanol, Tetrahydrofuran, Toluene, Xylene

##### Storage Precautions:

## UCSB Department of Chemistry and Biochemistry

- Store in approved flammable storage cabinet(s) (required if there is > 10 gallons in the lab).
- Separate from oxidizing acids and oxidizers.
- Keep away from any source of ignition (flames, localized heat or sparks).
- Use only "flammable storage" (desparked) refrigerator

**OXIDIZERS**-react violently with organics.

### Example Solids

Calcium Hypochlorite

Ferric Chloride

Iodine

Nitrates, Salts of

Peroxides, Salts of

Potassium Ferricyanide

Sodium Nitrite

### Liquids

Bromine

Hydrogen Peroxide

Nitric Acid

Perchloric Acid

Chromic Acid

### Storage Precautions:

- Keep away from organic solvents, and other combustible materials (i.e. paper, wood, etc.).
- Keep away from reducing agents.

**PEROXIDE-FORMING CHEMICALS**-peroxides can be explosive and shock-sensitive.

Ethers and acetals with alpha-hydrogen (e.g. ethyl ether, tetrahydrofuran); Alkenes with allylic hydrogen (e.g. cyclohexene). See *Distillations and Extractions* for more information.

**PYROPHORIC SUBSTANCES**-spontaneously ignite in air.

Examples: Some finely divided metals; Some organoaluminum compounds ( $\text{LiAlH}_4$ ,  $\text{Al}(\text{CH}_3)_3$ ); Silane; phosphorus, yellow (should be stored and cut under water)

### Storage Precautions:

- rigorously exclude air and water from container.
- store away from flammables.
- store in a cool, dry place.

**WATER REACTIVES** -react violently with water to yield flammable or toxic gases

### Storage Precautions:

- Rigorously avoid exposure to water and air.
- Store away from flammables
- Store in a cool, dry place.
- Lithium, Potassium, and Sodium should be stored under Kerosene or Mineral Oil

### **HIGHLY TOXICS, CARCINOGENS, REPRODUCTIVE TOXINS**

These chemicals can be very hazardous by themselves, or in combination with other chemicals. If they are easily inhaled, (gases and volatile liquids) then they are particularly hazardous. Suspected human carcinogens should also be stored as highly toxic. Access to lists of these three categories of materials are provided via web links in Sec. I of this *Chemical Hygiene Plan*.

Liquids - Seal tightly and store in a ventilated cabinet apart from incompatibles. Use secondary containment (e.g. plastic tub) to contain any spills.

Examples: Formaldehyde; Carbon disulfide; Mercury; Nickel carbonyl; Cyanide solutions

## UCSB Department of Chemistry and Biochemistry

Gases - Store in a gas cabinet or other ventilated cabinet

Chlorine; Fluorine; Hydrogen chloride; Nitric Oxide; Hydrogen Cyanide

Solids -Store away from incompatibles (usually acids) that would release toxic gas upon contact.

Examples: Cyanides, Salts of; Sulfides, Salts of



## REFRIGERATORS AND FREEZERS IN LABORATORIES

Certain refrigerator/freezer units are designed specifically for the storage of flammable materials, and to prevent potentially injurious explosions in your lab. These units have special protections to prevent ignition of flammable vapors. For example, the light switch, defrost feature, and thermostat inside the storage compartment have been removed or relocated. This is critical, since flammable vapors coupled with an ignition source could result in an explosion. In other words, a normal kitchen refrigerator is not safe for the storage of chemicals.

Before purchasing a new refrigerator/freezer, or using an existing one, consider whether chemicals will be used for storage in this unit. Note that many lab refrigerators will be around for decades and therefore one can not guarantee that a normal unit will never be used for flammables storage. There are two types of refrigerator/freezer models that should be considered, depending on the type of hazardous material the unit will store.

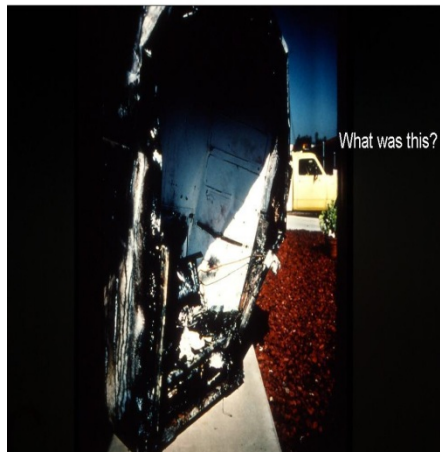
### I. FLAMMABLE MATERIAL STORAGE REFRIGERATORS/FREEZERS:

These have no internal electrical components which could trigger an explosion inside the unit. These must always be used for storage of volatile materials.

### II. EXPLOSION-PROOF REFRIGERATORS/FREEZERS :

These units prevent triggering of interior or exterior explosions in a hazardous environment. Every motor and thermostat is designed to prevent arcing and possible ignition. Used for storage of volatile materials in areas with explosive atmospheres. These are rarely necessary in lab environments.

All refrigerator/freezer purchases and modifications on campus **must be pre-approved** by EH&S at X8243. In addition, all approved refrigerator/freezer units storing flammable materials must be labeled with signage reading, "Approved For Chemical Storage, No Food Storage". All refrigerator/freezer units not approved for storage of flammable materials must be affixed with signage reading, "Explosion Hazard". Please feel free to contact EH&S for your free labels.



**This picture shows a UCI lab refrigerator which exploded when chemicals were inappropriately stored in a unit which was not designed for flammables storage.**

## GENERAL CHEMICAL SAFETY INFORMATION

### CARCINOGEN CONTROL

Since cancer in humans may result from exposure to chemical carcinogens, the following guidelines are designed to keep worker and environmental exposure to a minimum. In this two phase approach, good work practice is backed up by engineering controls.

Good work practice is the primary method of protecting laboratory personnel from exposure to chemical carcinogens.

- Substitute non-carcinogenic substances for chemical carcinogens wherever possible.
- Use and keep on hand very small quantities or dilute solutions of chemical carcinogens. (This reduces the magnitude of exposure in the event of a spill)
- Avoid inhalation as route of exposure.
  - Contain carcinogens in a fume hood or glove box.
  - Avoid practices which produce aerosols (blow-out pipets, sonicators, heating, stirring, pouring or weighing). Conduct these operations in a closed containment system).
  - Dry sweeping or dry mopping in the area is prohibited.
  - Wear EH&S approved respirators in areas where exposure may exceed the permissible level. Respirator users must be fit tested and approved by EH&S.
- Avoid skin contact as a route of exposure.
  - Wear gloves appropriate for the task. Change gloves often and remove before leaving the regulated area.
  - Wear a lab coat, but remove prior to leaving the controlled area
  - Clean up spills and contaminated containers as soon as discovered.
  - Wash hands and arms after each use of chemical carcinogens.
  - Clean work surfaces after each procedure and at the end of the work day.
  - Shower immediately after any overt exposure to chemical carcinogens.
- Avoid ingestion as a route of exposure.
  - Do not eat, drink, or smoke in the lab.
  - Use mechanical pipettes. Do not mouth pipette.
  - Thoroughly wash hands and arms before eating or smoking.
- Chemical Carcinogen Waste Disposal
  - EH&S will pick up carcinogen waste for proper disposal.
  - Do not dump carcinogens or toxic materials down the drain or evaporate
  - Do not dump carcinogens in the trash.

## GENERAL CHEMICAL SAFETY INFORMATION

### CHLORINATED SOLVENTS

**Examples:** methylene chloride, chloroform, trichloroethylene, dichloroethylene

#### Hazards

- Most of these compounds have an **anesthetic or narcotic effect**, causing people to feel intoxicated if overexposed. This can be particularly dangerous when working around machinery, as judgment and coordination can be impaired.
- Some of the chlorinated solvents are strong **systemic poisons** which damage the liver, kidneys, nervous system, and other organ systems. These symptoms most often appear gradually, with nausea, loss of appetite, vomiting, headaches, weakness, and mental confusion most common.
- All chlorinated solvents can cause **dermatitis** (chapping, drying, rashes) on repeated contact with the skin, since they remove the protective fats and oils. Gloves appropriate for a particular chlorinated solvent should be determined by consulting a **glove reference chart** – contained herein.
- Many of the compounds are highly **irritating** to the membranes around the eyes, and in the nose, throat, and lungs. Examples of chlorinated solvents which have irritating properties are ethylene dichloride and chloroform.
- In studies on laboratory animals, many chlorinated hydrocarbons have been linked to the development of **cancer** in animals; examples of these compounds are: ethylene dichloride, perchloroethylene, chloroform and methylene chloride. When excessively heated, chlorinated solvents can **decompose**, forming highly toxic fumes such as phosgene, hydrochloric acid, and chlorine.
- With few exceptions, most of the chlorinated hydrocarbons are **non-flammable**.

Work Practices: as with all volatile hazardous materials, chlorinated solvents must always be used in a fume hood or with other local exhaust ventilation such as an approved snorkel. Inhalation of the vapors is not an acceptable work practice.

## GENERAL CHEMICAL SAFETY INFORMATION

### NON-HALOGENATED SOLVENTS

#### *Hazard Properties:*

- Repeated contact can cause the skin's protective fats and oils to dissolve, resulting in reddening, itching and blistering.
- Can be readily absorbed through skin, producing systemic toxic effects.
- In addition to irritation of the respiratory tract and mucous membranes, inhalation can cause dizziness, drowsiness, headache, lack of coordination and nausea.
- Exposure over a prolonged period of time may result in damage to the liver, kidneys, lungs, blood, nervous system, and other organs. Carcinogenic, mutagenic and teratogenic effects are not uncommon
- Unlike most halogenated solvents, most non-halogenated solvents are flammable or combustible (see the subsequent section on Flammable Materials).

#### *Practices:*

- Use fume hoods to prevent inhalation of solvent and build-up of flammable levels of vapor. Minimize solvent vaporization by avoiding unnecessary open containers.
- Allow space for thermal expansion in containers; overfilling can cause rupture if they are filled nearly to the top with cold liquid and then stored in a warm area.
- Wear eye protection for all operations in which accidental splashing might occur.
- Substitute a less toxic solvent whenever possible.
- Avoid direct skin contact by using lab coat and solvent-resistant gloves

#### *Aromatic Hydrocarbons (Examples: benzene, toluene, xylenes, styrene)*

- Chronic exposure to a low concentration of benzene may damage the bone marrow, with resultant changes in blood cells. Benzene is considered carcinogenic, and has a relatively short latency period. Substitutes for benzene should be used.
- Aromatics defat the skin, and prolonged use causes drying, scaling and cracking. Readily absorbed through intact skin and may produce systemic toxic effects.
- The most commonly used aromatic solvents are flammable

#### *Aliphatic Hydrocarbons (Examples: hexanes, pentanes)*

- Typically lighter aliphatics are highly volatile and flammable with low flash points.
- Although not typically very toxic, the aliphatic hydrocarbons do cause many of the common symptoms related to organic solvent overexposure.
- N-hexane is unusual among aliphatic hydrocarbons as it is particularly toxic to the peripheral nervous system.

### *Ketones and Aldehydes (Examples: acetone, methyl ethyl ketone, cyclohexanone)*

- These chemicals are generally highly flammable.
- Typical effects are those of respiratory tract irritation, anesthesia, and dermatitis.

### *Ethers (Examples: ethyl ether, dioxane, glycol ethers) - See also Distillations & Extractions section*

- Many cause anesthetic effects and may be potent irritants and cause dermatitis.
- Glycol ethers may, in addition to the typical symptoms of organic solvent exposure, cause anemia (low red blood cell count) and have deleterious reproductive effects.
- The lower molecular weight ethers (e.g., diethyl ether) are highly volatile and are particularly hazardous flammable liquids.
- Can form explosive peroxides upon exposure to air (see Distillations and Extractions)

## GENERAL CHEMICAL SAFETY INFORMATION

### *FLAMMABLE MATERIALS*

Flammable and combustible materials are a common laboratory hazard. To minimize the risk of fire, all laboratory personnel should know the properties of the chemicals they are handling. MSDSs or other sources of information should be consulted for information such as vapor pressure, flash point, and explosive limit in air. In addition to fuel, an ignition source and an oxidizer are required for a fire to start. Users should be aware of any potential ignition sources in the immediate area including electrical equipment such as mechanical stirrers. A blanket of inert gas can be used to remove oxidizer (air) from the system. Some basic precautions for the safe handling of flammable materials include the following:

- Cap bottles and vessels when not in use. Use narrow-necked bottles and flasks for transferring to help reduce the release of flammable vapors.
- Never heat flammable substances with an open flame. Preferred heat sources include steam and water baths, oil baths, and heating mantles.
- Provide ventilation adequate enough to dilute the vapor concentration to below flammable levels rapidly. Working in a fume hood is an excellent way to achieve this.
- Use only refrigeration equipment that is certified for the storage of flammable materials.
- Metal containers and lines should be grounded to disperse static charges.
- Note that most flammable vapors are heavier than air and can travel long distances along bench tops and floors. Be aware of ALL potential ignition sources in the area, including those at a lower level than the work area.
- Know the location and proper use of laboratory fire extinguishers.

Flammable gases can rapidly produce an explosive atmosphere in the lab upon leakage or escape. Acetylene, hydrogen, ammonia, hydrogen sulfide, propane, and carbon monoxide are especially hazardous in this regard. Great care should be used when handling flammable gases. Precautions include working in a fume hood and enclosing larger cylinders in a ventilated gas cabinet. Installation of flash arresters on hydrogen cylinders is recommended. A reaction vessel should be triple flushed and purged with an inert gas prior to introduction of a flammable gas.

## GENERAL CHEMICAL SAFETY INFORMATION

### CORROSIVES (ACIDS AND BASES)

#### Examples:

**Acids – Solids:** benzoic acid, sulfamic acid. **Liquids:** acetic acid, nitric acid, phenol, sulfuric acid. **Gases:** hydrogen chloride, hydrogen fluoride, hydrogen bromide, chlorine, and sulfur dioxide.

**Bases- Solids:** sodium, potassium bismuth, and calcium hydroxides. **Liquids:** ammonium hydroxide, bromine, potassium hydroxide. **Gases:** ammonia

#### Hazard Properties:

- Corrosives can seriously burn body tissue on contact as well as cause dermatitis and eye damage.
- Exposure to vapors or mists can affect the respiratory tract and mucous membranes.
- Corrosives are not flammable, but they can react with each other and with other chemicals, causing potential fire and explosion.
- Contact with ordinary materials such as paper and wood may generate sufficient heat to ignite; especially true for oxidizing acids such as nitric and perchloric.
- Many corrosives may cause delayed injury, particularly bases. The absence of immediate symptoms may prolong exposure and as a result, cause even more severe injuries.

#### Practices:

- Be aware of the nearest eyewash station and emergency shower. If a chemical splash occurs, flush with running water for at least 15 minutes and seek medical attention.
- Use chemical splash goggles or other eye protection when working with acids/bases. Appropriate acid- and base-resistant protective clothing, including aprons, lab coats, and gloves, should also be worn.
- When diluting acids or bases with water, always pour the reagent slowly (while mixing) into the water, never the reverse.
- Hydrofluoric acid can cause severe chemical burns. See the EH&S website:  
<http://ehs.ucsb.edu/units/labsfty/labrsc/factsheets/lfacsheets.htm> for specific information on a recommended first-aid treatment paste that regular HF users should have on hand.
- Whenever acid, base or solvent bottles are carried to or from the laboratory, the bottles should be placed in buckets which act as secondary protective containers.

## GENERAL CHEMICAL SAFETY INFORMATION

### *DISTILLATIONS AND EXTRACTIONS*

#### Extractions

Before pouring a liquid into a separatory funnel, make sure the stopcock is closed and has been lubricated. Use a stirring rod to direct the flow of the liquid being poured. Keep a beaker under the funnel in the event the stopcock comes open unexpectedly. Do not attempt to extract a solution until it is cooler than the boiling point of the extractant. When a volatile solvent is used, the unstoppered separatory funnel should first be swirled to allow some mixing. Shake with a swirl holding the stopper in place and immediately open the stopcock. Repeat until it is evident that there is no excessive pressure. Swirl again as the funnel is racked, immediately remove the stopper, and separate when appropriate.

#### Distillations

##### **Permanent Solvent Stills**

**It is strongly recommended that all permanent solvent stills be equipped with cooling water flow sensors that automatically turn off the electricity to heating devices when the water flow drops below a "safe" rate.**

##### **Quenching Solvent Drying-Still Bottoms**

The process of quenching solvent drying still bottoms is potentially dangerous. If not handled properly, fire or explosion can result. Below are commonly-used good practices for this process - the info was adapted from UCI. Fortunately, solvent stills are becoming rarer on campus as they are replaced by the safer drying column method ("Grubbs apparatus") which does not employ solvent heating, or water-reactive drying agents.

When a distillation flask becomes discolored and filled with semi-solid material, it is time to start over with new solvent and drying material (usually sodium or lithium metal or a metal hydride). However, one must first "quench" the old flask. The quenching procedure should be performed as soon as possible to avoid the possible production of peroxides in the solvents. It is not a good idea to let the drying agents sit for weeks in the fume hood for passive quenching, especially if the solvent is a peroxide former.

If you see that the drying agent is coated with tar, proceed very slowly and cautiously in successive addition of alcohols with manual agitation from time to time. The key thing to remember when quenching these sorts of things is to be very PATIENT. Sometimes, the reaction takes a few minutes to get going, so it is easy to add a whole bunch and then have the reaction get out of control. Often, it is safer to let the reaction go overnight with alcohol if killing a large still with tar-coated drying agents.

##### **Quenching Steps**

The quenching operation must always be performed in a properly operating fume hood. There must not be any other flammables or explosives stored in the fume hood at the time. Have the appropriate fire extinguisher ready and refresh your memory on how to use it. Use safety glasses or goggles, and a face shield if desired. Wear the type of glove, e.g., nitrile, butyl rubber, that is non-permeable to the solvent in question. An apron or lab coat is recommended. Never perform this process with no one else around.

Obtain a container of sufficient size to hold both the still round-bottom flask and enough ice water to effectively cool the flask. Next, decant the bulk of any remaining solvent into an appropriate labeled container. If the still was neglected and there is a ball of metal surrounded by tar, it would be wise to make sure that there is a high boiling



point inert and relatively dry solvent (e.g. xylene) to keep the drying agent covered at all times and to act as a heat sink in case of sudden reaction. Place the flask into the ice water bucket; secure it with a clamp and ring stand if necessary to prevent it from falling over. You may want to use dry ice / acetone bath if solvent does not freeze at -78 degrees C to slow reaction. Keep the solution stirred either mechanically or by a spark-proof magnetic stirrer. Aim the mouth of the flask away from any people or equipment. If you are quenching a large volume use a blast shield. Use a pipette to add a small aliquot of sec-butanol. Perform the entire quenching operation under argon or nitrogen gas. If gaseous bubbles appear, wait until they stop, then add another small aliquot of sec-butanol. Continue this cautious step-wise addition until the generation of gaseous bubbles becomes very slow.

After the sec-butanol, try adding an alcohol with more freely available protons, like n-butanol. Continue the same cautious, step-wise approach until the gas bubble generation slows considerably. Remember to stir or swirl the flask occasionally, always keeping the mouth of the flask pointed away from anyone. Once you've used n-butanol, try the same step-wise cautious addition with these solvents in sequence: isopropanol, ethanol, methanol and water.

**Be Very Careful with the addition of WATER!** Even after methanol has been added, the drying agent can still react violently with water, especially if there hasn't been sufficient mechanical stirring of the solution. Mechanical stirring is vital because water is most dense and immiscible. It will sink to bottom with remaining solid to react vigorously.

Once the reaction with water is complete, use a suitable acid solution to neutralize the basic solution you've created. Good choices include 3 M HCl and citric acid, which may be easier to use. Add the acid in aliquots with the goal of obtaining a pH of 7. Don't be obsessive about obtaining this exactly; in the 5 - 9 range is OK. Pour this solution into a properly labeled waste container. In order to properly label the waste container with the percentages, you must keep track of the approximate amounts of the various solvents you used in this quenching process.

### References

- a) The Chemist's Companion by Gordon & Ford (lists drying agents with excellent comments about which solvents they work best with or should not be used at all)
- b) Prudent Practices in the laboratory, National Research Council (describes procedures for decomposing metal hydrides, alkali metals etc.)

### Spill and Accident Procedures

If one spills the unquenched flask, MOVE QUICKLY AWAY. The drying agent may spontaneously ignite in the air and the flammable solvent may cause a flash fire. Inform everyone in the immediate area and have them move to safe location.

If the spill is large, call the EH&S spill response team and inform them of the condition. There are two likely occurrences, the flammable solvent will evaporate and the alkali metal or metal hydride will oxidize with the moisture in the air. Or the alkali metal or metal hydride will react vigorously with a proton source (like water) and will generate hydrogen gas, which may spontaneously ignite with the heat of the reaction. If this occurs, EXIT and CALL the FIRE DEPARTMENT, the entire area may be quickly engulfed in flames.

If the spill is small, and doesn't contain any alkali metal or metal hydride, treat it as a flammable materials spill and 'dike' it with absorbent spill cleanup material, cover the spill with the absorbent then, once the spill is absorbed, sweep it into a bag for waste disposal.

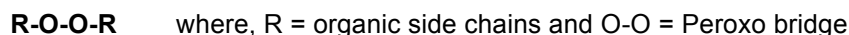
If the spill evaporates completely and leaves the slowly oxidizing alkali metal or metal hydride behind, gather these carefully into a beaker and quench with the same previously described procedure.

## Peroxides

Ethers must never be distilled unless known to be free of peroxides. Most ethers, including cyclic ethers, form **dangerously explosive peroxides** on exposure to air and light.

### What are organic peroxides?

Organic peroxides are a class of compounds that have unusual stability problems that make them among the most hazardous substances found in the laboratory. The lack of stability is due to the presence of an oxidation and reduction center within the same molecule.



As a class, organic peroxides are considered to be powerful explosives and are sensitive to heat, friction, impact, light, as well as to strong oxidizing and reducing agents. Peroxide-formers react with oxygen even at low concentrations to form peroxy compounds. The instability of the molecule (R-O-O-R) can cause auto-decomposition simply by bumping or jarring the container, addition of heat, light, or opening the cap.

**The risk associated with the peroxide increases if the peroxide crystallizes or becomes concentrated by evaporation or distillation. Peroxide crystals may form on the container plug or the threads of the cap and detonate as a result of twisting the lid.**

### *Classes of Peroxide Formers*

- Aldehydes
- Ethers - especially cyclic ethers and those containing primary and secondary alcohol groups
- Compounds containing benzylic hydrogen atoms (particularly if the hydrogens are on tertiary carbon atoms)
- Compounds containing the allylic structure, including most alkenes.
- Vinyl and vinylidene compounds.

### *Preventing Formation of Organic Peroxides*

No single method of inhibition of peroxide formation is suitable for all peroxide formers. Use of different inhibitors is discussed in the literature (0.001 to 0.01% hydroquinone, 4-tert-butylcatechol (TBC) or 2,6-di-tert-butyl-p-methylphenol (BHT)); however, limiting size of container and regular testing (every 3 months) and disposal is probably more effective (and certainly easier) for managing peroxide formation.

Ethers and other organic peroxide formers should be stored in cans, amber bottles, or other opaque containers, and ideally under a blanket of inert gas. It is preferable to use small containers that can be completely emptied rather than take small amounts from a large container over time. Containers of ether and other peroxide-forming chemicals should be marked with the date they are opened, and marked with the date of required disposal.

Common laboratory chemicals that form peroxides during storage include:

Acetal	Diisopropyl ether	Sodium amide
Butadiene	Dioxane	Styrene
Cumene	Dimethyl ether	Tetrahydrofuran
Cyclohexene	Divinyl acetylene	Tetrahydronaphthalene
Cyclooctene	Ethyl ether	Tetralin

## UCSB Department of Chemistry and Biochemistry

Decahydronaphthalene	Ethylene glycol dimethyl ether	Vinyl acetate
Decalin	Isopropyl ether	Vinyl acetylene
Diacetylene	Methyl acetylene	Vinyl chloride
Dicyclopentadiene	Methylcyclopentane	Vinyl ethers
Diethylene glycol	Potassium metal	Vinylidene chloride

### *Storing Peroxide Formers*

Mark on containers of time-sensitive materials both the date of receipt and the date the container is first opened. Time-sensitive materials should be marked with a tag to make them easily identified. No materials should be used or tested after the manufacturers' expiration date unless evidence of current stability has been obtained via direct testing prior to the expiration date.

**NOTE:** If material is old (> 1 year past label expiration date) then minimize handling and **DO NOT OPEN OR ATTEMPT TO TEST!** Call EHS (x-3293) to request special disposal for this item. Isolate the container from possible inadvertent use until picked up. If the material is very old or shows evidence of conversion to a hazardous status (i.e., crystalline materials in/under cap of ethers), do not move the container!

### *Peroxide Detection Tests*

From *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*, 2011: The following tests will detect most (but not all) peroxy compounds and all hyperperoxides. Results of peroxide detection tests must be indicated on the container/tag with test date, test results/method, and initials of the authorized person conducting the test. NOTE: These tests should not be used for testing materials potentially contaminated with inorganic peroxides (i.e., potassium).

Option 1. Add 1-3 ml of the liquid to be tested to an equal volume of acetic acid, add a few drops of 5% potassium iodide (KI) solution and shake. The appearance of a yellow to brown color indicates the presence of peroxides.

Option 2. Addition of 1 ml of a freshly prepared 10% KI and 10 ml of an organic solution in a 25 ml glass cylinder should produce a yellow color if peroxides are present.

Option 3. Add 0.5 ml of the liquid to be tested to a mixture of 1 ml of 10% KI solution and 0.5 ml of dilute hydrochloric acid to which a few drops of starch solution have been added just before the test. The presence of a blue-black color within a minute indicates the presence of peroxides.

Option 4. Peroxide test strips that turn an indicative color in the presence of peroxides. Take care to follow manufacturer instructions for effective detection. In general, the strips must be air dried until the solvent evaporates and then exposed to moisture for proper operation.

## GENERAL CHEMICAL SAFETY INFORMATION

### *SOP for the Use of Pyrophoric/Water Reactive Reagents*

Pyrophoric and water reactive materials can ignite spontaneously on contact with air, moisture in the air, oxygen, or water. Failure to follow proper handling procedures can result in fire or explosion, leading to serious injuries, death and/or significant damage to facilities.

Any handling of a pyrophor/water reactive material is high risk and must be controlled with adequate system design, direct supervision and training. These tasks are two person tasks and workers should not work alone.

#### **Examples of Pyrophoric/Water Reactive Materials**

- Grignard Reagents: RMgX (R=alkyl, X=halogen)
- Metal alkyls and aryls: Alkyl lithium compounds; tert-butyl lithium
- Metal carbonyls: Lithium carbonyl, nickel tetracarbonyl
- Metal powders (finely divided): Cobalt, iron, zinc, zirconium
- Metal hydrides: Sodium hydride, lithium aluminum hydride
- Nonmetal hydrides: Diethylarsine, diethylphosphine
- Non-metal alkyls: R3B, R3P, R3As; tetramethyl silane, tributyl phosphine
- White and red phosphorus
- Group I (Alkali) metals: Lithium, potassium, sodium, sodium-potassium alloy (NaK), rubidium, cesium.
- Gases: Silane, dichlorosilane, diborane, phosphine, arsine

**Hazards:** Because these reagents ignite on contact with air and/or water, they must be handled under an inert atmosphere and in such a way that rigorously excludes air/moisture. Some are toxic and many come dissolved or immersed in a flammable solvent. Other common hazards include corrosivity, teratogenicity, water reactivity, or peroxide formation, and may damage to the liver, kidneys, and central nervous system.

**Controlling the Hazards:** BEFORE working with pyrophoric or water reactive reagents, read the relevant Material Safety Data Sheets (MSDS), technical bulletins, and guidance documents to understand how to mitigate the hazards. The MSDS must be reviewed before using an unfamiliar chemical and periodically as a reminder. Users of reactive materials must be trained in proper lab technique and be able to demonstrate proficiency. Do not work alone or during off hours, when there are few people around to help. ALWAYS wear the appropriate personal protective equipment.

Remove all excess and nonessential chemicals and equipment from the fume hood or glove box where pyrophoric or water reactive chemicals will be used. This will minimize the risk if a fire should occur. Keep combustible materials, including paper towels and Kimwipes, away from reactive reagents. Keep the amount of pyrophoric or water reactive material present in your lab to the smallest amount practical. Use and handle the smallest quantity practical. It is better to do multiple transfers of small volumes than attempt to handle larger quantities (greater than about 20 mL). Alternatively, an appropriately engineered system, capable of safely handling the larger quantity must be designed, tested and properly used.

#### **Personal Protective Equipment (PPE)**

##### **Eye Protection**

## UCSB Department of Chemistry and Biochemistry

A full face shield that meet the ANSI Z.87.1 1989 standard must be worn whenever handling pyrophoric chemicals (should have "Z87" stamp on it). Prescription eye glasses, safety glasses, and splash goggles will NOT provide adequate protection. A face shield, worn over safety eyewear, is required any time there is a risk of explosion, splash hazard or a highly exothermic reaction.

All manipulations of pyrophoric chemicals which pose these risks must be carried out in a fume hood with the sash in the lowest feasible position.

### **Skin Protection**

In general, chemical protective gloves are unacceptable when working with pyrophors. If the reactive material were to ignite and spill onto the hand, nitrile or latex gloves would also ignite and contribute to serious injury. Nomex and related aramid fiber products are excellent fire retardant, but can significantly reduce dexterity. A Nomex flight glove (used by pilots to protect from heat and flash) works well.

**A fire retardant lab coat must be worn.** Special fire-resistant lab coats made from Nomex or other fire resistant materials are more expensive, but recommended for labs using these reagents routinely. Lab coats need to be buttoned and fit properly to cover as much skin as possible. Clothing, shirt and pants, should be cotton or wool. **Synthetic clothing is strongly discouraged.** Appropriate shoes that cover the entire foot (closed toe, closed heel, no holes in the top) must be worn.

### **Safety Equipment**

Researchers working with reactive materials must have the proper equipment and the emergency phone number (9-911) readily available for any emergencies, prior to starting research activities. Acceptable extinguishing media include soda ash (lime) or *dry* sand to respond to fires. DO NOT use water to attempt to extinguish a pyrophoric/reactive material fire as it can actually enhance the combustion

of some of these materials, e.g. metal compounds. A small beaker of dry sand or soda ash (lime) in the work area is useful to extinguish any small fire that occurs at the syringe tip and to receive any last drops of reagent from the syringe. Review the MSDS for the proper fire extinguisher to use with the given material.

### **Eyewash/ Safety Shower**

A combination eyewash/safety shower should be within 10 seconds travel time where reactive chemicals are used. Inside the laboratory is optimum. If a combination eyewash/safety shower is not available within the lab, an eyewash must be available (within 10 seconds travel distance) for immediate emergency use within the lab. Bottle type eyewash stations are not acceptable. A combination eyewash/shower must be available in the hallway or similar, within 10 seconds travel distance and accessible through only one door.

### **Fume Hood**

Many reactive chemicals release noxious or flammable gases upon decomposition and should be handled in a laboratory hood. In addition, some pyrophoric materials are stored under kerosene (or other flammable solvent), therefore the use of a fume hood (or glove box) is required to prevent the release of flammable vapors into the lab.

### **Glove (dry) box**

Inert atmosphere glove boxes are an excellent device for the safe handling of reactive materials. Glove boxes used for this purpose should be in good working order and the moisture and oxygen levels of the atmosphere should be confirmed prior to introduction of reactive compounds into the box. Continuous monitoring of oxygen and moisture is highly recommended. Also, take into account interactions between items in the glove box (e.g., nitrogen is not an inert gas for lithium metal as the lithium is reduced violently to lithium nitride).

### **Gas Cabinets**

Storage of pyrophoric gases is described in the CA Fire Code, Chapter 41. Gas cabinets, with remote sensors and fire suppression equipment, are required. Gas flow, purge and exhaust systems should have redundant controls to prevent pyrophoric gas from igniting or exploding. Emergency back-up power should be provided for all electrical controls, alarms and safeguards associated with the pyrophoric gas storage and process systems.

### **Storage and Disposal**

#### **Storage**

- Use and store minimal amounts of reactive chemicals. Do not store reactive chemicals with flammable materials or in a flammable liquids storage cabinet. Containers carrying reactive materials must be clearly labeled with the correct chemical name, in English, and hazard warning.
- Store reactive materials as recommended in the MSDS. An inert gas-filled desiccator or glove box are suitable storage locations for most materials.
- If pyrophoric or water reactive reagents are received in a specially designed shipping, storage or dispensing container (such as the Aldrich Sure/Seal packaging system) ensure that the integrity of that container is maintained.
- Ensure that sufficient protective solvent, oil, kerosene, or inert gas remains in the container while the material is stored.
- NEVER return excess chemical to the original container. Small amounts of impurities introduced into the container may cause a fire or explosion. For storage of excess chemical, prepare a storage vessel in the following manner:
  - Dry any new empty containers thoroughly
  - Insert the septum into the neck in a way that prevents atmosphere from entering the clean dry (or reagent filled) flask.
  - Insert a needle to vent the flask and quickly inject inert gas through a second needle to maintain a blanket of dry inert gas above the reagent.
  - Once the vessel is fully purged with inert gas, remove the vent needle then the gas line. To introduce the excess chemical, use the procedure described in the handling section, below.
  - For long-term storage, the septum should be secured with a copper wire (figure 1A).
  - For extra protection a second same-sized septa (sans holes) can be placed over the first (figure 1B).
  - Use parafilm around the outer septa and remove the parafilm and outer septum before accessing the reagent through the primary septum.

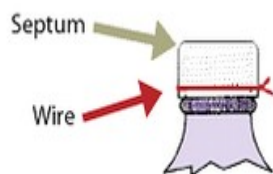


Fig. 1A Septum wired to vessel

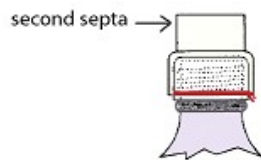


Fig. 1B For long-term storage, use a second septum

### **Disposal of Pyrophoric Reagents**

- Any container with a residue of reactive materials should never be left open to the atmosphere.
- Any unused or unwanted reactive materials must be destroyed by transferring the materials to an appropriate reaction flask for hydrolysis and/or neutralization with adequate cooling.
- The empty container should be rinsed three times with an inert dry COMPATIBLE solvent; this rinse solvent must also be neutralized or hydrolyzed. The rinse solvent must be added to and removed from the container under an inert atmosphere.
- After the container is triple-rinsed, it should be left open in back of a hood or ambient atmosphere at a safe location for at least a week.
- The empty container, solvent rinses and water rinse should be disposed as hazardous waste and should not be mixed with incompatible waste streams.

### **Disposal of Pyrophoric or Water Reactive Contaminated Materials**

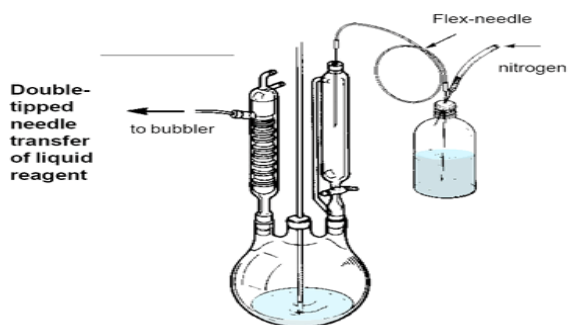
- All materials – disposable gloves, wipers, bench paper, etc. - that are contaminated with pyrophoric chemicals should be disposed as hazardous waste. Proper and complete hazardous waste labeling of containers is vital.
- The contaminated waste should not be left overnight in the open laboratory but must be properly contained to prevent fires.

**Important Steps to Follow:** Reactive reagents can be handled and stored safely as long as all exposure to atmospheric oxygen and moisture or other incompatible chemicals is avoided. Finely divided solids must be transferred under an inert atmosphere in a glove box. Liquids may be safely transferred without the use of a glove box by employing techniques and equipment discussed in the Aldrich Technical Information Bulletin AL-134. Pyrophoric gases must be handled in compliance with the California Fire Code, Chapter 41. Another good reference is "Manipulation of Air-sensitive Compounds" by Shriver and Drezdson. The California Fire Code prohibits the storage or use of pyrophorics in buildings not fully protected by an automatic sprinkler system. If you are using a pyrophoric in an unsprinklered building contact EH&S at x-4899 immediately so that we may assist you with the options available to mitigate the situation.

### **Handling Pyrophoric Liquids**

- Users should read and understand the Aldrich Technical Information Bulletin No. AL-134. The PI should also have in place laboratory-specific handling, storage, and disposal standard operating procedures. The standard operating procedures should be included in the lab Chemical Hygiene Plan.
- By using proper syringe techniques, these reagents can be handled safely in the laboratory. The Aldrich Sure/Seal™ Packaging System provides a convenient method for storing and dispensing air-sensitive reagents. Schlenk glassware is another suitable option.

- The reagent can be dispensed using a syringe or double-tipped needle (cannula) (16, 18 or 20 gauge) inserted through the hole in the metal cap, as shown in fig. 2 below. It is recommended that the plastic cap be replaced after each use and in particular for long-term storage.
- For extended storage of unused reagents, use the solid plastic cap, or equip the bottle with an Oxford Sure/Seal valve cap, or transfer the reagent to a suitable storage vessel, as described above.



**Fig. 2** Double-tipped needle transfer of liquid reagent

### Emergency Procedures

#### Spill

- DO NOT use water to attempt to extinguish a reactive material fire as it can actually enhance the combustion of some reactive materials, e.g. metal compounds.
- Do not use combustible materials (paper towels) to clean up a spill, as these may increase the risk of igniting the reactive compound. Soda ash (powdered lime) or dry sand should be used to completely smother and cover any small spill that occurs.
- A container of soda ash (powdered lime) or dry sand should be kept within arm's length when working with a reactive material.
- If anyone is exposed, or on fire, wash with copious amounts of water, except if metal compounds are involved, which can react violently with water. In the case of a metal fire, smothering the fire is a better course of action.
- The recommended fire extinguisher is a standard dry powder (ABC) type. Class D extinguishers are recommended for combustible solid metal fires (e.g., sodium, LAH), but not for organolithium reagents.
- Call 9-1-1 for emergency assistance and for assistance with all fires, even if extinguished.
- Pyrophoric gas releases and associated fires, should be extinguished by remotely stopping the gas flow. NEVER ATTEMPT TO PUT OUT A GAS FIRE IF THE GAS IS FLOWING.

#### Sources and Acknowledgements:

Created from a variety of sources including: Brandeis University, Standard Operating Procedure for Pyrophoric Chemicals; University of Nebraska, Lincoln, Pyrophoric Chemicals Standard Operating Procedure; University of Pittsburgh Safety Manual, Flammable and Pyrophoric Gas; Rochester University, SOP for Pyrophoric Chemicals. Images from Sigma-Aldrich Technical Bulletins AL-134 and AL-164. Personal communication with (and grateful acknowledgement to) Dr. Russell Vernon, Environmental Health and Safety, UC, Riverside; Dr. Joseph Pickel, Center for Nanophase Materials



## UCSB Department of Chemistry and Biochemistry

Sciences, Oak Ridge National Laboratory; Dr. Neal Langerman, Principal, Advanced Chemical Safety, Inc.; Dr. Frank Osterloh, Professor of Chemistry, UC Davis.

### *SOP for safe use of Pyrophoric Organolithium Reagents*

Storage, transfer and use of organolithium reagents including (but not necessarily limited to):

#### **Alkyls –**

- Methyl-d3-lithium, as complex with lithium iodide solution 0.5 M in diethyl ether
- Methyllithium lithium bromide complex solution
- Methyllithium solution purum, ~5% in diethyl ether (~1.6M)
- Methyllithium solution purum, ~1 M in cumene/THF
- Methyllithium solution 3.0 M in diethoxymethane
- Methyllithium solution 1.6 M in diethyl ether
- Ethyllithium solution 0.5 M in benzene/cyclohexane (9:1)
- Isopropyllithium solution 0.7 M in pentane
- Butyllithium solution 2.0 M in cyclohexane
- Butyllithium solution purum, ~2.7 M in heptane
- Butyllithium solution 10.0 M in hexanes
- Butyllithium solution 2.5 M in hexanes
- Butyllithium solution 1.6 M in hexanes
- Butyllithium solution 2.0 M in pentane
- Butyllithium solution ~1.6 M in hexanes
- Butyllithium solution technical, ~2.5 M in toluene
- Isobutyllithium solution technical, ~16% in heptane (~1.7 M)
- sec-Butyllithium solution 1.4 M in cyclohexane
- tert-Butyllithium solution purum, 1.6-3.2 M in heptane
- tert-Butyllithium solution 1.7 M in pentane
- (Trimethylsilyl)methyllithium solution 1.0 M in pentane
- (Trimethylsilyl)methyllithium solution technical, ~1 M in pentane
- Hexyllithium solution 2.3 M in hexane
- 2-(Ethylhexyl)lithium solution 30-35 wt. % in heptane

#### **Alkynyls –**

- Lithium acetylide, ethylenediamine complex 90%
- Lithium acetylide, ethylenediamine complex 25 wt. % slurry in toluene
- Lithium (trimethylsilyl)acetylide solution 0.5 M in tetrahydrofuran
- Lithium phenylacetylide solution 1.0 M in tetrahydrofuran

#### **Aryls –**

- Phenyllithium solution 1.8 M in di-n-butyl ether

#### **Others –**

- 2-Thienyllithium solution 1.0 M in tetrahydrofuran
- Lithium tetramethylcyclopentadienide
- Lithium pentamethylcyclopentadienide

#### **Hazards**

In general these materials are pyrophoric; they ignite spontaneously when exposed to air. This is the primary hazard and reagents must be handled so as to rigorously exclude air/moisture. They all tend to be toxic and come dissolved in a flammable solvent. Other common hazards include corrosivity, teratogenicity, water reactivity, peroxide formation, along with damage to the liver, kidneys, and central nervous system. On 12/29/2008 a UCLA lab employee, wearing nitrile gloves, safety glasses but no a lab coat, with three months' work experience in this lab was transferring an aliquot of t-butyllithium in pentane when the syringe plunger popped out or was pulled out of the

syringe barrel. The employee was splashed with the pyrophoric and flammable solution; upon contact with air the mixture immediately caught fire. The fire ignited the gloves and a sweater she wore. She suffered 3rd degree burns to 40% of her body and died about three weeks later.

### **Controlling the Hazards**

BEFORE working with pyrophoric reagent, read the relevant Material Safety Data Sheets (MSDS) and understand the hazards. The MSDS must be reviewed before using an unfamiliar chemical and periodically as a reminder. Pyrophorics users must be thoroughly-trained in proper lab technique and working alone with pyrophorics is strongly discouraged. Set up your work in a laboratory fume hood or glove box and ALWAYS wear the appropriate personal protective equipment. Minimize the quantity of pyrophoric reagents used and stored. The use of smaller syringes is encouraged. If handling more than 20 ml of sample - one should use a cannula for transfer or use a 20 ml syringe repeatedly.

### **Personal Protective Equipment (PPE)**

#### **Eye Protection**

- Chemical Splash goggles or safety glasses that meet the ANSI Z.87.1 1989 standard must be worn whenever handling pyrophoric chemicals. Ordinary prescription glasses will NOT provide adequate protection unless they also meet this standard. When there is the potential for splashes, goggles must be worn, and when appropriate, a face shield added.
- A face shield is required any time there is a risk of explosion, large splash hazard or a highly exothermic reaction. All manipulations of pyrophoric chemicals which pose this risk should occur in a fume hood with the sash in the lowest feasible position. Portable shields, which provide protection to all laboratory occupants, are acceptable.

#### **Skin Protection**

- Gloves must be worn when handling pyrophoric chemicals. Nitrile gloves should be adequate for handling most of these in general laboratory settings but they are combustible. Be sure to use adequate protection to prevent skin exposures. Sigma-Aldrich recommends the use of nitrile gloves underneath neoprene gloves<sup>2</sup>.
- *A lab coat or apron* (not made from easily ignited material like nylon or polyester) *must be worn*. Special fire-resistant lab coats made from Nomex are more expensive, but recommended for labs using these reagents routinely.
- No open toe shoes are allowed

#### **Equipment and Notification**

Have the proper equipment and the phone number for the Police (9-911) readily available for any emergencies.

#### **Designated Area**

##### ***Eyewash***

Suitable facilities for quick drenching or flushing of the eyes should be within 10 seconds travel time for immediate emergency use. Bottle type eyewash stations are not acceptable.

##### ***Safety Shower***

A safety or drench shower should be available within 10 seconds travel time where pyrophoric chemicals are used.

### **Fume Hood**

Many pyrophoric chemicals release noxious or flammable gases and should be handled in a laboratory hood. In addition, some pyrophoric materials are stored under kerosene (or other flammable solvent), therefore the use of a fume hood (or glove box) is required to prevent the release of flammable vapors into the laboratory.

### **Glove (dry) box**

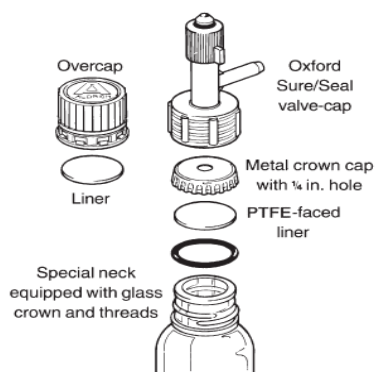
Glove boxes are an excellent device to control pyrophoric chemicals when inert or dry atmospheres are required.

### **Important Steps to Follow**

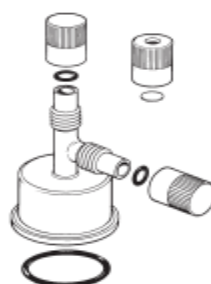
By using proper syringe techniques, these reagents can be handled easily in the laboratory.

### **The Aldrich Sure/Seal™ Packaging System**

The Sure/Seal packaging system (**Fig. 1A**) provides a convenient method for storing and dispensing air sensitive reagents. The reagent can be dispensed using a syringe or double-tipped needle (16, 18 or 20 gauge) inserted through the hole in the metal cap. When inserting a needle through a septum, a layer of silicone or hydrocarbon grease on the septum will help. Upon withdrawal of the needle, the small hole that remains in the PTFE liner will not cause the reagent to deteriorate under normal circumstances. However, it is recommended that the plastic cap be replaced after each use and in particular for long-term storage. For extended storage of unused reagents, use the solid plastic cap, or equip the bottle with an Oxford Sure/Seal valve cap, or transfer the reagent to a suitable storage vessel. The Sure/Seal septum-inlet transfer adapter (**Fig. 1B**) can be used when repeated dispensing is necessary. The adapter protects the contents of the bottles from air and moisture.



**Fig. 1A** Sure/Seal components

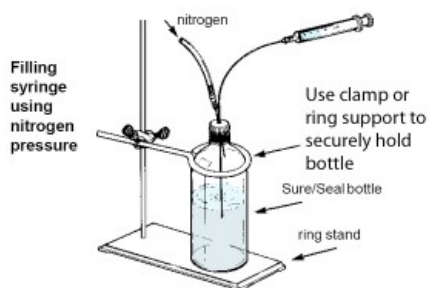


**Fig. 1B** Sure/Seal septum-inlet transfer adapter

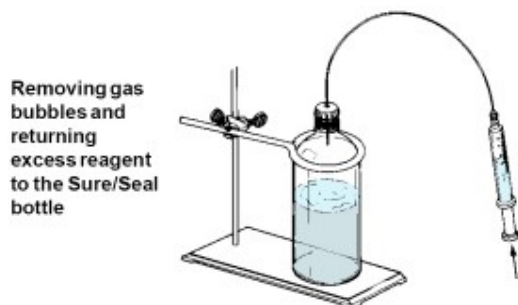
### **Transferring Pyrophoric Reagents with Syringe**

- In a fume hood or glove box, clamp the reagent bottle to prevent it from moving
- Clamp/secure the receiving vessel too.

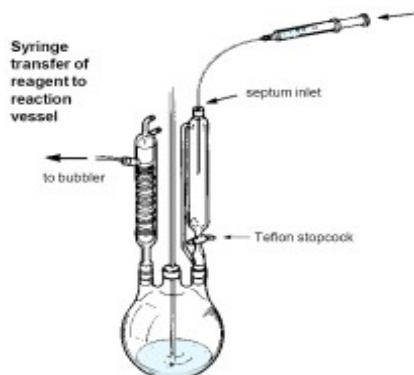
- After flushing the syringe with inert gas, depress the plunger and insert the syringe into the Sure/Seal bottle with the tip of the needle below the level of the liquid
- Secure the syringe so if the plunger blows out of the body it, and the contents will not impact anyone (aim it toward the back of the containment)
- Insert a needle from an inert gas source carefully keeping the tip of the needle above the level of the liquid
- Gently open the inert gas flow control valve to slowly add nitrogen gas into the Sure/Seal bottle.
- This will allow the liquid to slowly fill the syringe (up to 100mL) as shown in **Fig. 2A**. Pulling the plunger causes gas bubbles.
- Let nitrogen pressure push the plunger to reduce bubbles. Excess reagent and entrained bubbles are then forced back into the reagent bottle as shown in **Fig.2B**.
- The desired volume of reagent in the syringe is quickly transferred to the reaction apparatus by puncturing a rubber septum as illustrated in **Fig. 2C**.



**Fig.2A** Filling syringe using nitrogen pressure



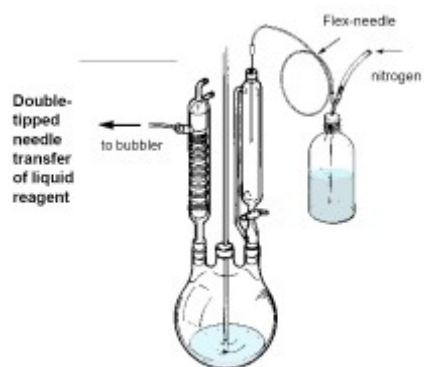
**Fig. 2B** Removing gas bubbles and returning excess reagent to the Sure/ Seal bottle



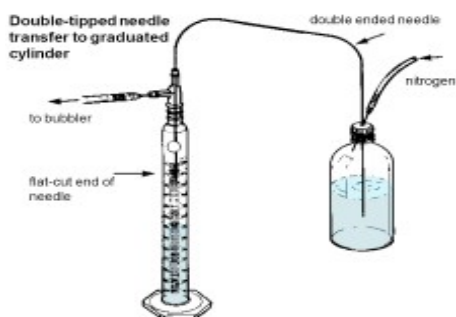
**Fig. 2C** Syringe transfer of reagent to reaction vessel

***Transferring Pyrophoric Reagents with a Double-Tipped Needle***

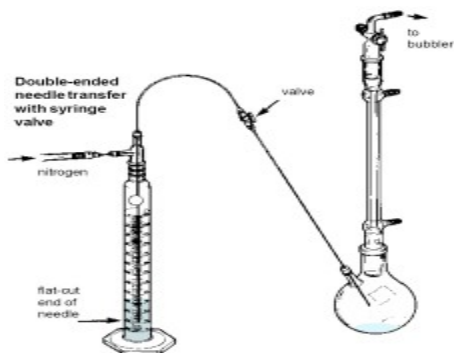
- The double-tipped needle technique is recommended when transferring 50 mL or more.
- Pressurize the Sure/Seal bottle with nitrogen and then insert the double-tipped needle through the septum into the headspace above the reagent. Nitrogen will pass through the needle. Insert the other end through the septum at the calibrated addition funnel on the reaction apparatus. Push the needle into the liquid in the Sure/ Seal reagent bottle and transfer the desired volume. Then withdraw the needle to above the liquid level. Allow nitrogen to flush the needle. Remove the needle first from the reaction apparatus and then from the reagent bottle. **(Fig. 3A)**
- For an exact measured transfer, convey from the Sure/Seal bottle to a dry nitrogen flushed graduated cylinder fitted with a double-inlet adapter **(Fig. 3B)**. Transfer the desired quantity and then remove the needle from the Sure/Seal bottle and insert it through the septum on the reaction apparatus. Apply nitrogen pressure as before and the measured quantity of reagent is added to the reaction flask.
- To control flow rate, fit a Luer lock syringe valve between two long needles as shown in **(Fig. 3C)**.



**Fig. 3A:** Double tipped needle transfer of liquid reagent



**Fig. 3B:** Double tipped needle transfer to graduated cylinder



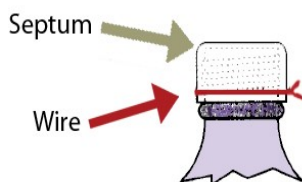
**Fig. 3C:** Double ended needle transfer with syringe valve.

## Storage

- Pyrophoric chemicals should be stored under an atmosphere of inert gas or under kerosene as appropriate.
- Avoid areas with heat/flames, oxidizers, and water sources.
- Containers carrying pyrophoric materials must be clearly labeled with the correct chemical name and hazard warning.

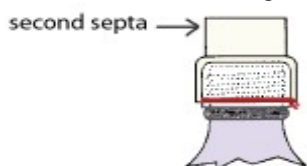
### For storage prepare

- a storage vessel with a septum filled with an inert gas o Select a septum that fits snugly into the neck of the vessel
- Dry any new empty containers thoroughly
- Insert septum into neck in a way that prevents atmosphere from entering the clean dry (or reagent filled) flask.
- Insert a needle to vent the flask and quickly inject inert gas through a second needle to maintain a blanket of dry inert gas above the reactive reagent.



**Fig. 4A** Septum wired to vessel

- Once the vessel is fully purged with inert gas, remove the vent needle then the gas line.
- For long-term storage, the septum should be secured with a copper wire (**figure 4A**).



**Fig. 4B** For long-term storage, use a second septum

- For extra protection a second same-sized septum (sans holes) can be placed over the first (**figure 4b**).
- Use parafilm around the outer septa and (obviously) remove the parafilm and outer septum before accessing the reagent through the primary septum.

## Disposal of Pyrophoric Reagents

- A container with any residue of pyrophoric materials should never be left open to the atmosphere.
- Any unused or unwanted pyrophoric materials must be destroyed by transferring the materials to an appropriate reaction flask for hydrolysis and/or neutralization with adequate cooling.
- The essentially empty container should be rinsed three times with an inert dry solvent; this rinse solvent must also be neutralized or hydrolyzed.
- After the container is triple-rinsed, it should be left open in back of a hood or atmosphere at a safe location for at least a week. After the week, the container should then be rinsed 3 times again.

### ***Disposal of Pyrophoric Contaminated Materials***

- All materials that are contaminated with pyrophoric chemicals should be disposed of as hazardous waste.
- Alert EH&S for any wastes contaminated by pyrophoric chemicals.
- The contaminated waste should not be left overnight in the open laboratory but must be properly contained to prevent fires.

### **Emergency Procedures**

#### ***Spill***

Powdered lime should be used to completely smother and cover any spill that occurs. A container of powdered lime should be kept within arm's length when working with a pyrophoric material. If anyone is exposed, or on fire, wash with copious amounts of water.

- The recommended fire extinguisher is a standard dry powder (ABC) type. Class D extinguishers are recommended for combustible solid metal fires (e.g., sodium, LAH), but not for organolithium reagents.
- Call 9-911 for emergency assistance

- 
1. Created from a variety of resources, principally the Sigma-Aldrich Technical Bulletins and these websites:  
[www.safety.rochester.edu/ih/standops8.html](http://www.safety.rochester.edu/ih/standops8.html) & [www.brandeis.edu/ehs/labs/pyrophoric.html](http://www.brandeis.edu/ehs/labs/pyrophoric.html) another good resource is  
Advanced Practical Organic Chemistry by J. Leonard, B. Lygo, and G. Procter esp. pages 76-98  
Another good resource is this article from the American Chemical Society.
  2. Private communication to Rebecca Lally ([rrlally@uci.edu](mailto:rrlally@uci.edu)) at UC Irvine in January 2009
  3. Images and advice from Sigma-Aldrich Technical Bulletins AL-134 and AL-164 at:  
<http://www.sigmaaldrich.com/chemistry/aldrich-chemistry/tech-bulletins/tech-bulletin-numbers.html>



## GENERAL CHEMICAL SAFETY INFORMATION

### *SOP for the Use of Hydrofluoric Acid*

HF is extremely corrosive to all tissues of the body and great care must be exercised in its use. If at all possible, other materials should be substituted for HF and its use avoided. No one should use HF until they have studied the laboratory Chemical Safety Summary (LCSS) or MSDS and discussed its use with more experienced lab personnel.

#### **Hazards**

Hydrofluoric acid is extremely corrosive to all tissues of the body. Skin contact results in painful deep-seated burns that are slow to heal. Burns from dilute (<50%) HF solutions do not usually become apparent until several hours after exposure; more concentrated solutions and anhydrous HF cause immediate painful burns and tissue destruction. HF acid burns become visually apparent as a blistered, red/purple burn that will eventually lead to a white spot on the skin surface. HF burns pose unique dangers distinct from other acids such as HCl and H<sub>2</sub>SO<sub>4</sub>: undissociated HF readily penetrates the skin, damaging underlying tissue; fluoride ion can then cause destruction of soft tissues and decalcification of the bones. Hydrofluoric acid and HF vapor can cause severe burns to the eyes, which may lead to permanent damage and blindness. At 10 to 15 PPM, HF vapor is irritating to the eyes, skin, and respiratory tract. Exposure to higher concentrations can result in serious damage to the lungs, and fatal pulmonary edema may develop after a delay of several hours. Brief exposure (5 min) to 50 to 250 PPM may be fatal to humans. Ingestion of HF can produce severe injury to the mouth, throat, and gastrointestinal tract and may be fatal.

Information about the properties of liquid HF in 5% or lower concentration has not been found. The use of very dilute HF is encouraged over the more concentrated forms, however users should treat it with great respect.

#### **Personal Protective Equipment**

All users of liquid HF must wear safety glasses (with side splash guards) and gloves. It is recommended that users wear 2 or more sets of gloves as a protection barrier to possible HF acid contamination. The first set of gloves, adjacent to the skin surface should consist of either vinyl or latex gloves. The second layer should consist of purpose built HF acid handling gloves, it is generally recommended that Trionic (a 19mm thick, purpose blended glove of latex, neoprene and carboxylated nitrile) gloves are designated specifically as HF acid handling gloves. The first set of gloves provides limited protection but prevents possible skin contact with HF during application and removal of the second set of gloves.

The use of full face shields and fore arm protection is strongly encouraged. A lab coat would be appropriate forearm protection. For any procedures requiring agitation of HF acid, a rubber apron is recommended as a substitute for the lab coat.

HF should be purchased and used with small (500 ml or less) bottles that allow easy and controlled pouring.

Calcium gluconate gel should be applied to any skin areas contacted with HF within seconds of contact. It must be readily available **before** any use of HF. This can be purchased from [www.calgonate.com](http://www.calgonate.com) or [www.attminerals.com](http://www.attminerals.com).

#### **Engineering/Ventilation Controls**

Liquid HF handling should be confined to the inside of a fume hood. This fume hood should be designated as a HF acid handling area and should be located in a low traffic area of the laboratory to prevent spills or accidents from contact.

If HF has to be measured by mass, it should be approximately measured in a plastic graduated cylinder inside a fume hood, then transferred to an appropriate container inside the fume hood, and then carefully moved to a lab balance.

### **Special Handling Procedures and Storage Requirements**

Liquid HF should be stored in appropriate "Acid" storage cabinets. In these cabinets, it should be within a plastic tray for additional secondary containment. HF should be stored in separate secondary containment trays from other acids with an "Acid" storage cabinet. Other chemicals, especially organics, solvents, and bases should never be stored with HF.

### **Spill and Accident Procedures**

Laboratory personnel should be familiar with first aid procedures before beginning work with HF; calcium gluconate gel should be readily accessible in areas where HF exposure potential exists.

First aid must be started within seconds in the event of contact of any form. In the event of skin contact, immediately wash with water for 15 min and remove contaminated clothing. If available, apply calcium gluconate gel. Obtain medical attention at once, and inform attending physician that injury involves HF rather than other acid. In case of eye contact, promptly wash with copious amounts of water for 5 min while holding the eyelids apart and seek medical attention at once. If HF is ingested, obtain medical attention immediately. If HF vapor is inhaled, move the person to fresh air and seek medical attention at once.

In the event of a spill of dilute hydrofluoric acid; soak up the acid with an HF-compatible spill pillow or neutralize with lime, calcium gluconate, or another mild base; transfer material to a polyethylene container; and dispose of properly, in a labeled storage medium used only for HF acid. Use personnel protective equipment as described above. Respiratory protection may be necessary in the event of a large spill or release in a confined area.

In any spill, alert any other people working in the lab to the hazard. For a large spill, contact campus EH&S at 893-3914 for assistance.

### **Waste Disposal**

Waste HF should be collected for disposal with campus EH&S. HF acid should under no circumstances be disposed down the drain. All solutions containing HF must be collected and disposed of using correctly label storage vessels. It should not be mixed with other acids or solvents. HF should be collected for disposal in well labeled plastic containers. Dilute salts mixed in with the HF are not a problem. Any material used to soak up suspected HF acid during spills or normal use must be placed in a plastic bag labeled as HF waste and disposed of correctly. Never throw spill pillows or absorbent material in the normal trash.

### **Decontamination**

Materials contaminated with HF may be washed with copious amounts of water in a lab sink. It is generally accepted that equipment and plastic-ware must be washed for at least 6 minutes under flowing water before drying. Proper use of HF acid requires specifically labeled equipment and plastic-ware for use with HF that are labeled as HF only, kept in and around the HF acid handling area and used with HF only.

## GENERAL CHEMICAL SAFETY INFORMATION

### *SOP for the Use of Strong Oxidizers*

#### Hazards

- Irritating to the eyes, respiratory system and skin.
- Contact with combustible material may cause fire.
- Heating may cause an explosion.
- May be highly toxic, toxic if swallowed, very toxic by inhalation, or show limited evidence of a carcinogenic effect.
- Hazardous decomposition products may occur, including carbon monoxide, carbon dioxide and nitrogen oxides.

#### Personal Protective Equipment

- Compatible chemical resistant gloves
- Chemical safety glasses or goggles
- Government approved respirator if levels cannot be controlled below acceptable exposure levels using a chemical fume hood.

#### Engineering Controls

- Use only in a chemical fume hood.
- Safety shower and eye wash must be within a 10 second travel time from work area.

#### Handling Procedures and Storage Requirements

- Wash hands thoroughly after handling. Remove and wash contaminated clothing promptly.
- Storage
  - Keep containers tightly closed.
  - Keep away from combustible materials, heat, sparks, and open flame.
  - Keep away from strong bases, reducing agents, finely powdered metals, organic materials, aluminum and sulfur. May react violently with benzene, calcium hydride, charcoal, olefins, alcohols, strontium hydride, sulfuric acid.
  - Some chemicals in this class require refrigeration between 2-8 °C.
  - Some Class IV oxidizers cannot be stored in unsprinklered buildings.

**Consult individual MSDS for specific handling and storage requirements.**

#### Accident Procedures

- If swallowed, wash out mouth with water if person is conscious. Call a physician.
- If inhaled, remove to fresh air. If breathing becomes difficult, call a physician.
- In case of skin contact, flush with copious amounts of water for at least 15 minutes. Remove contaminated clothing and shoes. Call a physician.
- In case of contact with eyes, flush with copious amounts of water for at least 15 minutes. Assure adequate flushing by separating the eyelids with fingers. Call a physician.
- 

#### Spill Procedures

- Evacuate immediate spill area. If spill is large, OR if spill is small but you are unsure of procedure or hazard level involved, call EH&S at ext.3194
- If spill is small AND you feel confident in your ability to manage it:
  - **Liquids:** Absorb onto sand or vermiculite and place in a sealed and labeled container for disposal.
  - **Solids:** Sweep up gently, avoiding raising dust. Place in a sealed and labeled container for disposal.
  - Request waste container pickup from EH&S.

## UCSB Department of Chemistry and Biochemistry

### **Waste Disposal**

Place all strong oxidizer waste into a dedicated waste container. Container must be made of material compatible with the waste (see **Handling Procedures and Storage Requirements** section above). Affix a completed UCSB hazardous waste label to the container and contact EH&S for disposal.

### **Designated Areas**

Indicate with appropriate signage where the strong oxidizer is to be used. Use only within this designated area.

## GENERAL CHEMICAL SAFETY INFORMATION

### *SOP for the Use of Picric Acid*

Picric acid (also known as trinitrophenol) is a pale yellow, odorless crystal that is slightly soluble in water and highly sensitive to heat, shock, or friction. Because of picric acids explosive nature it is among the most hazardous substances found in the laboratory.

#### Hazards

- Flammable solid when wetted with more than 30% water and a high explosive with less than 30% water.
- Shock, heat and friction sensitive.
- Toxic by all routes of entry (i.e., inhalation, ingestion, dermal)
- Skin irritant and allergen.
- Will produce toxic products on decomposition.
- Highly reactive with a wide variety of materials (e.g., copper, zinc, lead, salts, plaster, concrete, ammonia, etc.).
- Extremely susceptible to the formation of picrate salts by the reaction of picric acid with any of the following: metals, metal salts, bases, ammonia and concrete. Many of these salts are even more reactive and shock sensitive than the acid itself.

Water can be added to picric acid to act as a desensitizer. The wetted product is considerably less shock sensitive than the dry acid.

**Note: Picric acid must never be allowed to dry out, especially on metal or concrete surfaces.**

#### Handling Procedures

Please refer to the MSDS and any relevant publications such as *Prudent Practices in the Laboratory* for detailed handling procedures. **It is very important that all of the available information regarding the use of picric acid be thoroughly reviewed by all parties before any work begins.** Determine the potential hazards before beginning an experiment.

- If possible, engineer out the use of picric acid if another product will perform the same task with less potential for risk.
- Keep an accurate and up-to-date chemical inventory of all laboratory spaces to reduce the potential for old and overlooked picric acid.
- All work with picric acid should be done in a chemical fume hood to minimize inhalation exposure.
- Wear the proper protective equipment: lab coat with sleeves fully extended to the wrist, eye protection such as splash goggles, neoprene gloves, full-length trousers, closed toe shoes. Under no circumstances should disposable gloves ever be reused!
- Use and store the least amount of picric acid that the work requires rather than purchasing larger quantities.
- Keep in clearly labeled (including date received), compatible containers.
- Perform a dry run to work out the potential pitfalls before actually using picric acid.
- Know the location of all safety equipment, including eyewash/douse showers and the first aid kit, emergency telephone numbers and who to notify in the event of an emergency, and keep your coworkers informed as to your activities regarding picric acid activities.

#### Storage

Containers of picric acid should be placed in polyethylene secondary containers (large enough to contain the entire contents if the original container should rupture) and stored with all other inorganic acids. Be sure to label all containers that contain picric acid (including date received).

**Potentially old picric acid is an item of special concern.** If old or previously unaccounted for bottles of picric acid are discovered, the following steps should be taken.

## UCSB Department of Chemistry and Biochemistry

- Most importantly **DO NOT TOUCH THE CONTAINER!** Depending on how long the bottle has been left and the state of the product inside, even a minor disturbance could be dangerous. Crystals may have formed between the lid and the container. Any attempt to open the container could result in an explosion large enough to do serious damage to personnel and equipment.
- Visually inspect the container for product identification and check for an expiration date. If the product is relatively new, there may not be a problem. Nevertheless, treat the situation carefully.
- Inspect the contents of the bottle to determine water content and check for signs of crystallization inside the bottle and around the lid. If there is no evidence of crystal formation and the water content is fairly high, there is probably little cause for concern. If there is even the slightest indication of crystallization or low levels of water in the bottle, the situation is more serious. Contact EH&S immediately for guidance! Immediately secure the area and restrict access. A measure of security can be obtained by lightly misting any attainable crystals (such as those that may have formed on the outside of the bottle) with large quantities of water. A water spray bottle is ideal for this purpose.
- Dry picric acid or picrate salts should not be touched or moved under any circumstances. This is a serious potential hazard.

If you feel that your laboratory may have old picric acid in your chemical inventory, contact EH&S (893-3293) for a special pick-up to have it removed, **but do not handle it yourself.**

### Disposal

All picric acid waste should be properly packaged with a hazardous waste label affixed to it. Contact EH&S for disposal.

### Accidents

- For medical assistance call 9-911 and also inform EH&S at ext. 3194.
- If the exposure is through skin contact use the nearest eyewash/safety shower and immediately begin flushing with water for at least fifteen minutes.
- Remove all contaminated clothing.
- Make sure all exposed areas are rinsed; victim will need assistance to hold eyes open in water if necessary.
- Be sure an MSDS is available for the medical personnel.

## GENERAL CHEMICAL SAFETY INFORMATION

### *SOP for the Use of Perchloric Acid*

#### Hazards

Due to its strong oxidizing and corrosive properties, perchloric acid is one of the most hazardous substances in the lab and has been associated with many accidents. Hazards include:

- When used above ambient temperature, and/or greater than 72% concentration, perchloric acid has an unusual hazard in that acid fumes can condense in fume hood ventilation systems to form metallic perchlorates that can be **explosive**. There have been accidents in which explosions from perchlorate-contaminated hoods have resulted in injuries and even death.
- Reacts violently with organic materials (e.g. wood, paper, solvents), particularly if heated, or in concentrations greater than 72%.
- Likewise, certain perchlorate salts of organic and heavy metal cations are explosive and can be set off by heat or shock. The ammonium, alkali metal and alkali earth perchlorates are somewhat more stable. Old synthetic preps calling for other cations should be seriously questioned.
- When concentrated (>72%, or anhydrous) the acid can be spontaneously explosive.
- The acid is very corrosive to skin, eye tissue and mucous membranes.

#### Handling

- If possible, engineer out the use of perchloric acid.
- Evaporations in fume hoods should **only** be done in a special perchloric acid "wash down" hood. These hoods do not allow the buildup of explosive perchlorate salts by keeping the acid in solution. Contact EH&S for further information on these hoods (x4899).
- All work should be done in a well-ventilated area separated from organic materials. All work with >85% perchloric should only be done after consultation with EH&S.
- Wear the proper protective gear: flame resistant lab coat, splash goggles, rubber gloves, closed shoes.
- Storage: place the acid container inside a secondary container, such as a plastic tub, that will capture the liquid if the bottle breaks or leaks. Store in a separate, labeled ("Oxidizers") lab area (i.e. cupboard) fully away from organic materials. Don't store on wooden shelves, or with paper shelf liners.

#### Accidents

- For skin or eye exposure, immediately wash with water for at least 15 minutes. Seek medical attention for serious exposures. Know the location of nearest emergency shower and eyewash.
- Be sure an MSDS is available for the medical personnel.
- If the material is spilled, isolate the spill from any organic materials. Dilute with water to ~5% if possible. Absorb the spill with vermiculite - organic absorbents (e.g., paper) **must not** be used. Contact EH&S at x-3194 if you are not equipped to safely deal with the cleanup.

#### Disposal

Package and properly label waste per normal waste procedures (x-3293). Complete and submit Waste Pickup Request Form - available for electronic submission at <http://ehs.ucsb.edu>.

## GENERAL CHEMICAL SAFETY INFORMATION

### SOP for the Use and Generation of Azide Ion and Organic Azides

#### Hazards

- Azide ion has a similar toxicity as that of cyanide ion (LD<sub>50</sub> = 27 mg/kg for rats).
- Organic azides are potentially-explosive substances that can and will decompose under heat, light or pressure.
- Small molecules containing azido functionality tend to decompose violently which may result in injury if proper safety precautions are not utilized.

#### Handling

##### General:

- Use only in the chemical fume hood. Minimize dust generation and accumulation.
- Wear the proper protective gear: flame resistant lab coat, splash goggles, rubber gloves, closed shoes.
- Avoid contact with eyes, skin and clothing.

##### Sodium Azide:

- Sodium azide can react violently with several common laboratory organics such as: CS<sub>2</sub>, bromine, Bronstead acids, and heavy metals. When attempting a new reaction, be relentless in your background research to determine the reactivity of sodium azide anions to all reaction components.
- **Never use chlorinated solvents as reaction media!** Using dichloromethane or chloroform will result in the formation of di- and tri- azidomethane, respectively (refer to section on C/N ratios below).

##### Organic Azides:

- All organic azides decompose with introduction of external energy. Any azide synthesized should be stored below room temperature (-18 °C) and in the dark.
- When designing your target azide, keep in mind the following equation.<sup>1)</sup> Notice that this equation takes into account all nitrogen atoms in your azide, not just those in the azido group. *N* signifies the number of atoms.  
$$N_c + N_o / N_N \geq 3 \text{ (eq. 1)}$$
- In practice, organic azides that contradict the above equation can be made, and in some cases, be stored safely. Consider the following points as strict guidelines in the preparation and storage of organic azides:
  - A small scale (ca. 0.5-1.0 g) should be run first to determine the nature of the product.
  - *n*-nonyl azide (C/N=3) will be the smallest azide isolated and stored in its pure form. This azide, when stored properly, can be done so in multigram quantities (up to 20 g). In practice, the octyl derivative is equally safe (C/N=2.7)
  - Azides smaller than C/N=3 (but greater than C/N=1) can be synthesized and isolated, but no means should these molecules be stored in its highest purity. Rather, if storage is necessary store these azides as solutions below room temperature (concentrated to no more than 1M, less than 5 g material). Explicit supervisor approval may be necessary before attempting synthesis.
  - Under no circumstances should azides with C/N<1 be isolated. However, these molecules may only be considered for synthesized if azide is a transient intermediate species, and the limiting reagent in the reaction mixture, and with maximum quantities of 1 g. Explicit supervisor approval may be necessary before attempting synthesis.



- **Never use distillation or sublimation as purification techniques!** Purification should be limited to extraction and precipitation. Column chromatography may contribute to decomposition. Only azides that satisfy eq.1 may be purified in this manner.

### **Disposal**

**Organic azide waste should be placed in a separate, explicitly-labeled waste container!**

Extra caution must be taken to make sure that azide waste not come in contact with acid. Acids will protonate any residual azide ion and form the highly-toxic hydrogen azide (with toxicity similar to that of hydrogen cyanide).

### Reference

1. Smith, P.A.S. Open-Chain Nitrogen Compounds, vol 2, Benjamin, New York, 1966, 211-265.

## GENERAL CHEMICAL SAFETY INFORMATION

### *SOP for the Use of Hydrogen Cyanide and Cyanide Salts*

#### Hazards

- **Hydrogen Cyanide and its salts are highly toxic.** Exposure by inhalation, **eye or skin contact**, or ingestion can be rapidly fatal, even at low levels.
- Poisoning can occur by inhalation of mists of cyanide salt solutions and by inhalation of HCN produced by the reaction of cyanide salts with acids **and even plain water!**
- Hydrogen cyanide gas is flammable. Its salts react with strong oxidizers, forming hazardous decomposition products including carbon monoxide and nitrogen oxides.

#### Handling

- Store in tightly closed containers.
- Store away from moisture, acids, heat or strong oxidizers.
- **Avoid all contact with skin, eyes, lungs or clothing.** Wear appropriate PPE: Lab coat, chemical resistant glove, safety glasses, closed toe shoes.
- Use proper glove removal technique (without touching glove's outer surface). Dispose of contaminated gloves in a sealed container with the appropriate hazardous waste tag affixed to it.
- Wash hands between operations, before breaks and at the completion of handling operations.
- All work is to be performed in a chemical fume hood. Do not allow dust to become airborne or mists of cyanide solutions to form.
- Be aware of the location of safety showers and eye washes.

#### Accidents

- If inhaled, remove victim to fresh air. Call 9-911 immediately.
- In case of skin contact, flush with copious amounts of water for at least 15 minutes. Remove contaminated clothing. Call 9-911 immediately.
- In case of contact with eyes, flush with copious amounts of water for at least 15 minutes. Assure adequate flushing by separating the eyelids with fingers. Call 9-911 immediately.
- In case of ingestion, if conscious wash out mouth with copious amounts of water. Call 9-911 immediately.
- Have an MSDS ready for emergency responders.
  
- If a fire occurs which involves or possibly involves cyanide-containing materials, **do not use a carbon dioxide (CO<sub>2</sub>) fire extinguisher**, as this could lead to the release of hydrogen cyanide gas from any cyanide salts present. Use a dry powder ABC fire extinguisher only.
- In case of spill of solid cyanide salts, isolate the area. If it is a small spill in a fume hood, sweep up carefully and avoid stirring up dust. If you are not comfortable doing this, or if the spill is outside of a fume hood or the airflow in the area is stirring up dust, evacuate the area and call EH&S at ext. 3194 immediately.
- In case of a spill of liquid cyanide-containing solutions, isolate the area. If it is a small spill in a fume hood, soak up the liquid with a spill pillow or absorbent material, place in a sealed container and affix a hazardous waste tag. If you are not comfortable doing this, or if the spill is outside of a fume hood, evacuate the area and call EH&S at ext. 3194 immediately.

#### Disposal

Waste material containing cyanide salts should be placed in a separate sealed container and labeled with a hazardous waste tag. Do not add acids to this waste, as lowering the pH could release toxic HCN gas. Call EH&S for prompt removal of cyanide waste.

## PHYSICAL HAZARDS

### COMPRESSED GAS CYLINDERS

Compressed gas cylinders must be handled carefully by trained individuals. The diffusive nature of gas can result in serious hazards over large areas. Gas cylinders can be hazardous because 1) if they are mishandled, they can become “unguided missiles” with enough explosive force to go through concrete walls due to the high pressure inside the tank. 2) they often contain materials which are inherently toxic or highly flammable. For these reasons, particular care must be exercised with compressed gases.

#### Use of Toxic Gases on Campus

Per *the CA Fire Code*, if the volume of toxic gas within a given building exceeds a particular amount, then expensive and elaborate gas monitoring and alarm systems are required. Therefore, EH&S works with departments and labs to reduce the volumes of these hazardous materials whenever possible.

Below is a list of common toxic gases that researchers could use. If you plan to use any of these, or other toxic gases, inform the EH&S Lab Safety Specialist at x4899 or x8243 before you proceed. In most cases the requirements of the Fire Code can be avoided by going to smaller gas cylinders and/or gas mixtures with inert gases.

- Arsine
- Boron Trichloride
- Boron Trifluoride
- Carbonyl Disulfide
- Chlorine
- Cyanogen
- Fluorine
- Germane
- Hydrogen Cyanide
- Hydrogen Fluoride
- Hydrogen Selenide
- Hydrogen Sulfide
- Methyl Bromide
- Methyl Mercaptan
- Nickel Carbonyl
- Nitric Oxide
- Nitrogen Dioxide
- Nitrous Oxide
- Phosgene
- Phosphine
- Silane

#### Transport

- To transport or move a cylinder, strap it to a **hand truck** in an upright position.
- Never drop cylinders or bang them against each other or another object.
- Do not move a cylinder by rolling, dragging or walking it across the floor. Never leave a cylinder free-standing.
- Make sure the **valve protection cap** and outlet plug are in place. Leave the valve protection cap on at all times, unless the cylinder is in use.

#### Storage

## UCSB Department of Chemistry and Biochemistry

- All cylinders must be secured upright with **chains and brackets** bolted to a solid structural member. Chains should be 3/16 inch welded link or equivalent. At least one chain must be used to secure each cylinder at a point two-thirds up the cylinders height. C-clamp bench attachments and fiber/web straps are not acceptable because they are not seismically sound. Any variations of these requirements must be approved by EH&S. (Campus Policy 5445)
- Keep cylinders away from heat and sources of ignition. Do not place cylinder where contact with any electrical circuit can occur. Protect cylinders from weather extremes, dampness and direct sunlight.
- Inspect cylinders and delivery equipment routinely for signs of wear, corrosion, or damage.
- All cylinders must be clearly labeled as to their contents — do not use unlabeled cylinders and do not rely on color coding for identification.
- Understand that “Empty” implies “end of service” and as such, the cylinder may still have greater than 25 psig of pressure remaining.

### Leaks

- If the material in the tank is **toxic or flammable** and you suspect a leak, get everyone out of the area and report it to EH&S at x3194 and Dispatch at 9-911.

### Use

- Gas delivery systems involving toxic gases must be authorized by EH&S prior to installation and operation.
- Use **regulators** designed for a specific gas. (Consult your gas vendor or catalog for proper regulator **compressed gas association (CGA) number** (on nut) for use with corresponding compressed gas cylinder. Do not use any adapter between cylinders and regulators.
- Post **signs** in laboratory area when using corrosive, toxic or flammable gases. The door placard system maintained by EH&S on the campus may be used for this.
- Never modify, adapt, force or lubricate safety devices, cylinder valve or regulator.
- Do not allow grease or oil to come into contact with **oxygen** cylinder valves, regulators, gauges or fittings. An explosion or fire can result. Oxygen cylinders and apparatus must be handled with clean hands and tools. Remember that oxygen supports and greatly accelerates combustion.
- Never force a gas cylinder valve — if it cannot be opened by the wheel or small wrench provided, the cylinder should be returned.
- When opening cylinder valve, do not hold regulator. Stand with valve between you and regulator. Open cylinder valves slowly, directed away from your face.
- Release a compressed gas gently to avoid build-up of static charge which could ignite a combustible gas.
- Special precautions are necessary for acetylene usage. Note that **acetylene** can form explosive compounds in contact with copper or brass. Consult the vendor or manufacturer for proper operating equipment and procedures.
- **Do not extinguish a flame** involving a highly combustible gas until source of gas has been shut off. Re-ignition can cause an explosion.

### Disposal

- Empty cylinders should be labeled "EMPTY" or "MT. Always leave at least 25 psi minimum pressure in all "EMPTY" cylinders to prevent contamination and the formation of explosive mixtures.
- Return damaged or corroded cylinders and cylinders with a test date **more than five years** old stamped on the shoulder to the vendor. Some gas cylinders should be disposed or returned at shorter intervals (e.g., **corrosives** should be disposed or returned every six months since they readily attack the cylinder fittings).

## PHYSICAL HAZARDS

### CRYOGENS

Examples: Liquid oxygen, liquid nitrogen, liquid helium, dry ice

#### Hazard Properties

- These materials are extremely cold (-100°C to -270°C) and, upon contact, can instantly freeze other materials. Serious tissue damage may occur upon exposure.
- Evaporating liquid nitrogen will displace the air within a non-ventilated space possibly leading to **suffocation**. Generally, labs have adequate ventilation to prevent this.
- Be aware of **ice that can plug or disable pressure-relief devices**. Ensure adequate pressure relief mechanisms are functional, i.e., never use tight-fitting stoppers or closures without pressure-relief devices.

#### Practices

- Do not move an **over-pressurized container**. Evacuate and seal area, call EH&S (x3194) or dial 9-911.
- Avoid trapping cryogenic liquids between closed sections of an apparatus.
- **Dewar flasks** or other glassware devices should be taped on the outside or provided with shatterproof protection to minimize flying glass particles in case of implosion. Dewar flasks should be vented with a bored or notched stopper.
- Cool cryogenic containers slowly to reduce thermal shock and flashing of the material.
- Cryogen handlers should be protected by a **face shield or safety goggles, lab coat or apron and gloves or mitts**.
- When utilizing cold baths with solvents, use in a hood with a catch pan. Be aware of increased fire hazard. Be prepared for **vigorous solvent boiling** upon initial addition of solvent.
- Avoid **condensing oxygen** (blue in color) and/or contact with organic material when using liquid nitrogen. Flush cold traps with nitrogen or keep under vacuum to avoid condensation of oxygen from air within the trap. Condensed oxygen when contacted with organic materials can cause a powerful explosion.
- **Liquid helium** requires approved handling techniques and equipment due to over-pressurization hazards and icing.

Check the glassware and valves for cracks and other defects before beginning experimental work. Verify that systems assumed to be under vacuum are so, particularly when using liquid nitrogen. You should be on the lookout for the possibility of condensed air within the apparatus.

Skin contact with liquid nitrogen may lead to a frostbite burn. An occasional droplet of nitrogen, such as is encountered when filling a Dewar, often does not freeze the skin because of insulating film gaseous nitrogen, which forms immediately. However skin is readily frozen if the liquid nitrogen is held on a spot by clothing which is saturated with the refrigerant, or by any other means which leads to extended contact.

**Storage:** Storage of liquid nitrogen: use only approved low temperature containers. Make sure liquid nitrogen containers are vented to prevent pressure buildup. You must use extreme care when working with liquid nitrogen. Liquid nitrogen should not be stored in sealed containers, as tremendous pressure could result and an explosion is possible.

**Spill and accident procedures:** Flood the area (skin and eyes) immediately with large quantities of cool water, apply cold compresses. See a doctor immediately if the skin is blistered or if the liquid nitrogen came in contact with your eyes.



## PHYSICAL HAZARDS

### VACUUM SYSTEMS

Vacuum systems have a variety of hazards associated with their operation. There are risks associated with implosion, as well as the release of toxic materials. The systems are typically complicated and require extensive training prior to use.

#### *General Safety*

- Understand the type of vacuum pumps being used and their limitations. Always check with the manufacturer for the appropriate application.
- Prepare for **power outages** whether you are present or not. Some valves close upon loss of power, some open. Understand the effects that a series of valve openings and closings will have upon the system's integrity.
- Always replace the pump **belt guard** to prevent catching fingers or clothing in the mechanism.
- Be aware of the hot surface in **oil diffusion pumps**
- If a glass vacuum line is ever used **above ambient pressure**, it should be shielded from personnel to prevent glass shards from flying if the line were to shatter.
- Glass vessels that are evacuated should be round-bottomed and/or thick-walled and designed for low-pressure work. They should be regularly checked for star cracks and scratches.
- The use of safety glasses is mandatory.

#### *Traps and Venting*

- Use of house vacuum systems must employ appropriate **traps** to prevent chemical, radioactive or biohazardous material from contaminating the building lines. Likewise, use of an aspirator should also employ a suitable trap to avoid contaminating the water stream.
- Mechanical vacuum pumps should be protected by **cold traps** – generally liquid nitrogen based.
- If hazardous materials are used with the vacuum system they should be located in, and **vented** to, a fume hood.
- Pump oil from vacuum system exhaust has been known to accumulate in building ductwork systems increasing the likelihood of fire spread. Pump exhaust should only be done **into the fume hood** proper, or if exhausted directly into building ductwork, an oil trap must be installed.
- Operation of low temperature traps must be thoroughly understood. Both the cooling and warming phases deserve undivided attention. For example, when using liquid nitrogen, the **condensation of air** due to an open valve may cause a serious explosion when the air vaporizes upon warming.
- **Dewar flasks are under high vacuum and are therefore subject to implosion.** They should be wrapped in tape or plastic sheathing.



## UCSB Department of Chemistry and Biochemistry

### Chemical Hazards

- Mechanical pump oil can become contaminated with hazardous materials that were being pumped on. Upon maintenance, proper protective equipment must be employed. A ventilated area should be used for changing pump oil, as harmful vapors may be released. Clean or contaminated pump oil must be disposed of as hazardous waste via EH&S.
- Mechanical pump exhaust may require suitable scrubbing for volatile highly toxic materials. This may involve a relatively simple filter or liquid bubbler.

### Practices

#### Turning ON a High Vacuum System:

- Make sure all valves are closed.
- Turn on vacuum pump.
- Place Dewar around trap flask
- Submerge trap flask in liquid nitrogen. **Make sure system is under vacuum before cooling trap to avoid condensation of liquid oxygen.**

#### Turning OFF a High Vacuum System

- Remove all samples and experiments from vacuum line.
- Remove trap flask from Dewar. Allow to warm to room temperature
- Open vacuum system to atmosphere. **Do not do this while trap is cold to avoid condensation of liquid oxygen.**
- Turn off pump.

## PHYSICAL HAZARDS

### *High Pressure Reaction Vessels*

#### **General Safety**

Perform high-pressure operations only in special chambers equipped for this purpose. Commercially available high pressure reactor vessels are designed and manufactured to ensure safe operation when used within the temperature and pressure limits for which they are rated. Any documentation and manuals that pertain to the reactor vessel in use must be thoroughly read and understood. However, in the end it is the user's responsibility to make sure that the selected vessel is compatible with the reagents and conditions to which it will be exposed during the experiment.

To this end, the user must:

- Select a vessel which has the capacity, pressure rating, corrosion resistance and design features that are suitable for its intended use.
- Operate the vessel within a suitable barricade, if required.
- Establish training procedures to ensure that any person handling the equipment knows how to use it properly.
- Maintain the equipment in good condition, and test periodically to ensure that the vessel is remains structurally sound.
- Complete a hazard assessment before initiating the experiment, including:
  - Assessment of any intermediates, side-products and products that may form and their behavior within the vessel, including their corrosive nature and their tendency to violently decompose at elevated temperature and pressure.
  - Determination of maximum temperature and pressure limits expected, taking into account the energetics of the reaction being conducted and any pathways that might cause the reaction to run out of control.
- Maintain adequate ventilation. This can be achieved by installing the reactor within a fume hood, attaching tubing to the rupture disk that extends to an appropriate exhaust such as the interior of a fume hood, or by ensuring that the lab area as a whole has adequate ventilation and that the reactor is installed near an exhaust fan (in the case of larger reactors).
- Run preliminary experiments using small quantities of reactants when starting work with new or unfamiliar materials.
- Use appropriate PPE, including safety glasses, chemical resistant gloves, a lab coat, and also a face shield for operations that present particular hazards.
- Keep a log of usage for each vessel. Information on the log should include temperature, pressure, reagents/solvents used, and any inspections and tests it has undergone.

#### **Particular Hazards of Note**

##### *Potentially Explosive Material*

There are a number of functional group categories whose presence within a structure is a common indication of explosive potential. Use of reagents containing these functional groups in a high pressure reactor is contraindicated. Some of these functional groups are:

- Metal acetylide
- Amine oxide
- Azide
- Chlorate
- Diazo and diazonium'
- Fulminate
- N-haloamine
- Hydroperoxide
- Hypohalite

## UCSB Department of Chemistry and Biochemistry

- Nitrate, nitrite, nitro and nitroso
- Ozonide
- Peracid
- Perchlorate
- Peroxide

### *Loading Limits*

Overloading of a pressure vessel is a significant hazard. Dangerous pressures can develop suddenly and unexpectedly when a liquid is heated in a closed vessel if adequate head-space is not available to accommodate the expansion of the liquid. **This is particularly true of water and aqueous solutions, whose volume may increase up to a factor of three when heated to 374 °C.**

A vessel must **never** be filled to more than three-fourths of its available free space. Frequently, the maximum fill level must be reduced even more to insure safe operation. If a table of volume multipliers is available for the solvent in use, use this data to calculate to maximum allowable loading using the formula:

$$\text{Max. Loading Volume} = (0.9)(\text{Vessel Volume})/\text{Volume Multiplier at Max. Temp.}$$

Volume multiplier tables for water can be found in “**Steam Tables : Thermodynamic Properties of Water Including Vapor, Liquid, and Solid Phases/With Charts**” Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill , Joan G. Moore, Krieger Pub Co, 1992, as well as in the Parr Instrument Company document No. 230M: “**Safety in the Operation of Laboratory Reactors and Pressure Vessels**”.

### *Limitations of the Material of Construction*

Pressure vessels of identical design but of differing materials of construction will have vastly different pressure and temperature limits, as well as differing corrosion resistance towards solvents and reagents (acids and bases in particular). The material of construction of the vessel must be known and its limitations understood before initiating an experiment. For commercial reactor vessels, the user's manual and other documentation is an excellent resource for this information.

### **Reference**

An excellent general reference for pressure vessel safety using vessels manufactured by Parr Instrument Corporation, as well as for general high pressure reactor safety is the Parr Instrument Company document No. 230M: “**Safety in the Operation of Laboratory Reactors and Pressure Vessels**”.

## PHYSICAL HAZARDS

### SEISMIC HAZARD REDUCTION

Earthquakes have occurred and will continue to occur in the Santa Barbara area. This is of particular concern in UCSB laboratories where the presence of hazardous materials, compressed gases, high voltage sources, etc., would pose serious hazards to individuals and buildings in a quake. In addition, the presence of expensive, difficult to replace lab equipment makes the need for evaluating the seismic anchoring needs of your lab critical.

#### Campus policies:

- All furnishings and equipment over 48 inches in height must be fastened to a wall or floor in a manner to prevent falling in an earthquake.
- Storage of large, heavy items must be kept below head level.
- All compressed gas cylinders must be secured individually to a solid structural member with 3/16 inch welded chain or equivalent bracing. At least one chain must be used to secure each cylinder at a point two-thirds up the cylinder's height. C-clamp bench attachments and fiber/web strap attachments will not be allowed. Any variations of these requirements must be approved by Environmental Health & Safety.
- Chemical storage shelving must have shelf lips or other restraining devices (e.g. wire or bungee cord along edge) installed to prevent chemicals from falling.
- To prevent accidental mixing of chemicals that could result in a fire, explosion or toxic release, incompatible chemicals must be segregated into separate, labeled areas or into separate rigid secondary containment such as plastic tubs. For more specific information on the classification and storage of particular chemicals consult the *UCSB Chemical Hygiene Plan* or contact EH&S at x-4899.

#### Recommended practices:

- While not a safety issue, there are often expensive pieces of lab equipment, e.g. electronics that you may wish to seismically anchor.
- Based on earthquake experiences at Cal State Northridge, UCLA and UCSC it is recommended that researchers maintain extra copies of irreplaceable files such as research data in a separate location.

#### Responsibility:

The responsibility for compliance and funding of these policies rests with the department Chair or department head. Lab supervisors are responsible for identifying and implementing areas where the above policies apply in their labs. Environmental Health & Safety will act in an advisory capacity.

## PERSONAL PROTECTION

### *CAMPUS POLICY ON PERSONAL PROTECTIVE EQUIPMENT (PPE)*

In July 2011 UCSB instituted a new policy on the use of personal protective equipment (PPE) in laboratories. The policy is intended to help protect lab workers from injury, meet regulatory requirements for worker protection and bring more consistency to PPE practices across the campus. All members of the lab community have responsibilities under the policy - particularly lab supervisors/faculty and lab workers. The full policy can be found at:




<http://www.policy.ucsb.edu/policies/policy-docs/lab-personal-protective-equip.pdf>

The key aspects of the policy are summarized on a wall poster which is mounted in all labs, or lab suites. **A copy of the poster is presented on the following page.** Other notable aspects of the policy are noted here, but the full policy should be consulted for details:

- The PPE requirements only apply when “handling” hazardous materials, not when an individual is simply in the same room with materials.
- Radiological and biological hazards are not covered by the policy. Instead, PPE for these is regulated by the Radiation and Biosafety Committees, respectively.
- Lab gloves must not be worn in public areas unless traveling to an adjacent lab space, or needed for protection while transporting materials between work areas – in which case clean gloves should be donned.
- Safety eyewear must meet American National Standards Institute (ANSI) requirements. This is denoted by the “Z87” stamp on the eyewear. Most reading glasses do not meet ANSI standards. Approved safety glasses can be worn over contact lenses, or splash goggles can be worn over reading glasses, or one can obtain prescription safety glasses.



**Personal Protective Equipment (“PPE”) Required for UCSB Laboratory Workers**

	CATEGORY 1: Significantly Hazardous Chemicals	CATEGORY 2: Hazardous Chemicals Not in Category 1	CATEGORY 3: Selected Physical Hazards
<p>This poster summarizes the key elements of the UCSB Laboratory Personal Protective Equipment Policy.</p> <p>The full Policy can be found at: <a href="http://www.policy.ucsb.edu/policies/az/">http://www.policy.ucsb.edu/policies/az/</a> (click on “L”)</p> <p>The full Policy is too detailed to be fully shown here and should be consulted as needed.</p> <p><b>MINIMUM PERSONAL PROTECTIVE EQUIPMENT REQUIRED</b></p>	<p><b>EXAMPLES<sup>b</sup>:</b></p> <ul style="list-style-type: none"> <li>Corrosives (above 5% by weight acids/bases)<sup>d</sup></li> <li>Flammables/Combustibles above one liter</li> <li>Materials Absorbed Through Skin</li> <li>Skin and Eye Irritants</li> <li>Highly Toxic and Neurotoxins</li> <li>Strong Air or Water Reactives, e.g. Pyrophorics<sup>e</sup></li> <li>Strong Oxidizing Agents</li> <li>Carcinogens and Reproductive Toxins</li> </ul>	<p><b>EXAMPLES<sup>b</sup>:</b></p> <ul style="list-style-type: none"> <li>Dilute Corrosives (below 5% by wt. acids/bases)<sup>d</sup></li> <li>Flammables/Combustibles less than one liter</li> <li>Liquid Cryogenics (LN<sub>2</sub> solvent/dry ice baths)</li> </ul>	<p><b>EXAMPLES<sup>b</sup>:</b></p> <ul style="list-style-type: none"> <li>Glassware under vacuum</li> <li>Vessels under pressure</li> <li>Mechanical hazards</li> <li>Hazardous chemicals not in Category 1,2</li> </ul>
<p><b>“ANSI-Approved” Safety Eyewear<sup>a</sup></b></p> 	YES	YES	YES
<p><b>Appropriate Laboratory Gloves<sup>c</sup></b></p> 	YES	YES	RECOMMENDED
<p><b>Lab Coat, or Fire-Resistant Lab Coat</b></p> 	YES (for flammables use fire-resistant coat)	RECOMMENDED	RECOMMENDED
<p><b>Close-toed Shoes and Long Pants</b></p> 	YES	RECOMMENDED	RECOMMENDED

The Policy prescribes the minimum PPE required, but can't foresee all circumstances. So, in some cases additional PPE may be needed to adequately protect workers and meet regulatory requirements. These requirements only apply when an individual is directly “handling” a material in such a way as to have a reasonable possibility of being exposed. Questions or feedback are welcome and should be directed to UCSB Environmental Health & Safety, x-4699, or x-8243.

**Footnotes**

- Meet *American National Standards Institute* standards as indicated by “Z87” stamp on frame. Most “reading glasses” do not meet this standard. Eyewear in campus storerooms meet ANSI standards, as do prescription safety glasses from optometrists. Alternatively, safety goggles may be worn over glasses.
- Consult container label or MSDS to verify chemical hazard class(es). Definitions and specific chemical examples are provided in the full Policy.
- Consult container label, MSDS or a Glove Reference Chart to determine appropriate glove. Glove charts are available via the EH&S Website and other sites.
- Definition of “dilute corrosive” as below 5% by weight is only for purposes of this Policy. Corrosives can have other properties requiring gloves at any concentration, e.g., HF acid is particularly penetrative/damaging to skin.
- While handling flammable liquids (particularly pyrophorics), it is strongly recommended that synthetic clothing not be worn which is more ignitable than cotton.

**Additional Policy Elements**

- ⇒ Lab gloves should not be worn in public areas except where clearly needed for personal protection, e.g., during transportation of some particularly hazardous materials
- ⇒ PPE for infectious biological agents and radioactive materials are not covered by this Policy. They are regulated independently by the campus Biosafety and Radiation Safety Committees, respectively.

### *Personal Protective Equipment (PPE) in UCSB Storerooms*

You can buy supplies from any campus storeroom. Using appropriate and comfortable personal protective equipment is important in eliminating or reducing your exposure to hazardous materials. For gloves particularly, it is critical that the glove material be matched to the chemical(s) that you are using. There is no such thing as a glove that is impervious to all chemicals.

The supplies noted below are only the basic PPE available. There are many more materials, styles and brands of PPE available thru safety products suppliers (e.g., *Fisher Scientific* and *Lab Safety Supply, Co.*). Contact EH&S (x-4899 or x-8787) if you need assistance.

#### **Biological Sciences Storeroom, Bldg. 569, x-2537 or 3234**

- **Gloves** - Nitrile; Latex (powdered); Vinyl examination; Wash gloves (Playtex); High/low temperature
- **Eyewear** - Goggles; Glasses
- **Lab coats** - Cotton (fire-resistant)
- **Sharps disposal** - Syringe/razor size; Broken glass box
- **Waste disposal bags** - Autoclaveable; Biohazard; Hazardous materials
- **First aid supplies** - Band-aids; Cotton

#### **Chemistry Storeroom, room 1432, x-2563**

- **Lab Coats** - Cotton (fire-resistant)
- **Gloves** - Nitrile; Latex; "Wash gloves"; Cleanroom glove (triple polymer)
- **Eyewear** - Glasses
- **Sharps disposal** - Syringe/razor size
- **First aid supplies** - Bandages; Gauze pads; Burn cream

#### **Physics Storeroom, Broida Hall, room 1301, x-2747**

- **Lab Coats** - Cotton (fire-resistant)
- **Gloves** - Nitrile; Neoprene; Latex; Vinyl; Wash gloves (Playtex); Canvas; Leather; Nylon; Finger cots (latex)
- **Eyewear** - Goggles; Glasses w/ side shields; "Neon"-colored glasses; "Malibu" glasses (wraparound)
- **Respirator** - Dust mask
- **Ear plugs** - foam type
- **Sharps disposal** - Broken glass box
- **Waste disposal** - Glass and plastic 1-gallon containers
- **First aid** - Band-aids

#### **University Center Bookstore, x-3271**

- **Eyewear** - Goggles; Glasses
- **Lab coats** - Cotton/polyester

## SELECTING THE PROPER GLOVES

The correct gloves protect the hands against chemicals; the wrong gloves enhance chemical contact. The type of glove used should be chosen to be compatible with the particular chemicals being used. **There is no universal glove that protects you from all chemicals. To choose the correct glove go to a Glove Reference Chart.** ( links below).

**Disposable gloves** provide minimal protection and should be used with this in mind. If using concentrated solvents, corrosives or toxics, more heavy-duty gloves should be worn. These provide more protection, but have the drawback of being more cumbersome. Note also that about 15% of the population is allergic to latex <http://www.cdc.gov/niosh/docs/97-135/> to some degree.

Check gloves before use for signs of wear or penetration. Disposable gloves can be inflated by mouth to check for pinholes. When removing gloves, be careful to avoid touching the outside of the gloves with your bare hands. Always remove gloves before leaving the lab.

All gloves are permeable, only the permeation rate varies, depending on the chemical, the glove material and thickness, temperature, concentration gradient, etc. However, once a material begins to permeate the glove, it will continue until an equilibrium is reached. You must, therefore, decide when it is appropriate to discard contaminated gloves.

**Glove Reference Charts (No guarantees are made regarding the accuracy of these charts. Recommend cross-checking at least two sites.)**

[http://www.coleparmer.co.uk/catalog/manual\\_pdfs/MicroflexChemChart.pdf](http://www.coleparmer.co.uk/catalog/manual_pdfs/MicroflexChemChart.pdf) (Microflex )

<http://www.bestglove.com/site/chemrest/default.aspx> (Best Co.)

[http://www.ansell-edmont.com/download/Ansell\\_7thEditionChemicalResistanceGuide.pdf](http://www.ansell-edmont.com/download/Ansell_7thEditionChemicalResistanceGuide.pdf)

<http://www.mapaglove.com/ChemicalSearch.cfm?id=0> (MAPA Professionals)

<http://www.showabestglove.com/site/chemrest/> (Showabest Gloves)



## Respirators

Modern laboratories incorporate engineering controls (e.g., fume hoods) that mitigate respiratory hazards. If, however, engineering or administrative controls are not possible or practical, then potentially exposed persons shall be enrolled in the EH&S Respiratory Protection Program. This program is designed to meet regulatory requirements and ensure the health and safety of those persons falling within the program. Legally, you cannot simply purchase a respirator and use it without contacting EH&S.





## FUME HOOD USAGE GUIDE

### STANDARD HOODS

*(standard hoods do not have the VAV control box shown on the next page)*

1. **Always work with the sash at the level of the red arrow sticker (picture on next pg.) and close it when not attended.** To adequately protect you, your hood should be producing a face velocity of about 100 ft/min. EH&S tests your hood and posts the red arrow stickers at the **proper sash level to:**
  - satisfy the required air flow and protect you (10 - 100 times more than full open sash) against airborne chemicals
  - protect you better from incidents within the hood
2. \*All hoods on campus are equipped with an air flow monitor and/or alarm to warn you if the air velocity is too low – see examples pictured below. **If the alarm engages, lower the sash slightly until the alarm stops.** Do **NOT** disengage or over-ride the alarm. If your alarm sounds consistently this could indicate a real problem – call EH&S.
3. Always work at least 6 inches inside the hood to maximize capture efficiency.
4. Store only a minimum of equipment and chemicals in your hood because:
  - Excess materials will block the air flow into the intake slots at the back of the hood. Permanent equipment should be raised on a jack to allow the air to flow smoothly.
  - Most fires and explosions occur in the hood. Minimizing chemical volumes will reduce the chances of a small accident escalating into a large one.
5. Keep the lab windows closed. Drafts from open windows and doors can significantly affect your hood's performance (100 ft/min is only a few miles/hr of air).



\*“Magnehelic gauge” – note normal gauge position. Significant deviation may indicate low air flow.

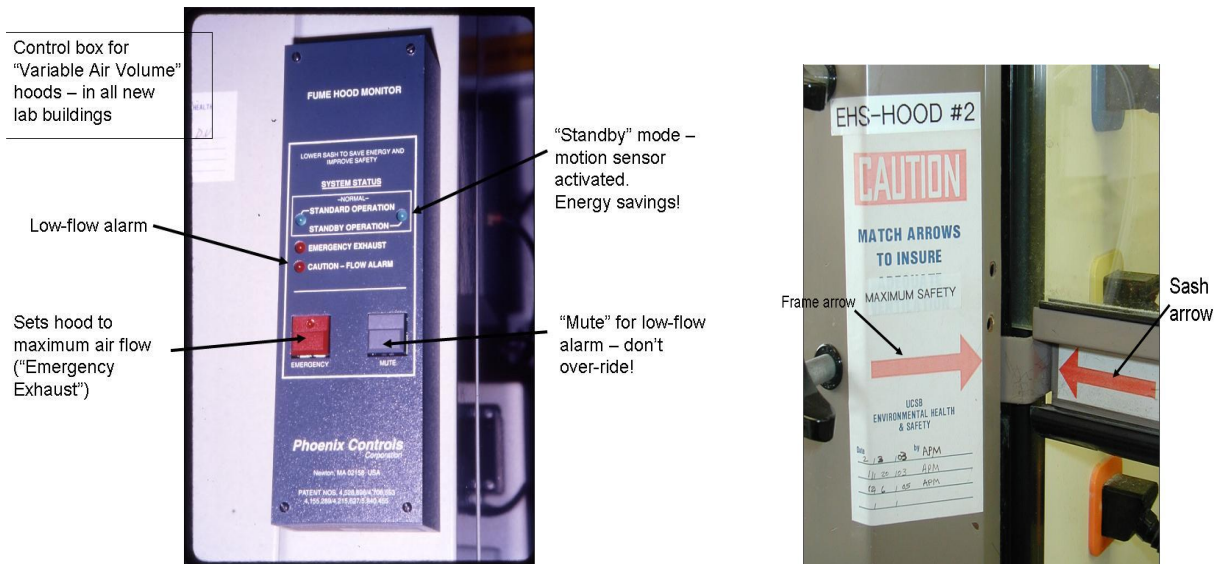


\*Visible/audible alarm  
Sounds during low-flow condition

VARIABLE AIR VOLUME (VAV) HOODS

Variable Air Volume (VAV) hoods — unlike a standard hood above — automatically adjust the face velocity to stay within recommended safe work levels (~ 100 ft./min). A VAV hood is easily distinguished by the gray control box on the hood – pictured below.

1. **If the low-flow alarm engages, lower the sash until the alarm stops.** DO NOT over-ride the safety alarm by permanently engaging the "Mute" or "Emergency" button (e.g., with tape). If your hood is consistently alarming call EH&S (x-4899).
  
2. Always work with the sash at or below the level of the **red arrow sticker** (below), because:
  - o If most bldg. sashes are raised, this will generate a hood alarm, and at your neighbor's hood, due to the limited capacity of your building's ventilation
  - o A lowered sash protects you against airborne chemicals and incidents up to 100 times more than at sash full open.
  - o The lower the sash, the greater the **energy conservation** – lower sash when not in use
  
3. Store only the minimum of equipment and chemicals in your hood because:
  - o Excess materials block air flow into the slots at back of the hood. Permanent equipment should be raised on a stand to allow the air flow into the lower slot.
  - o Most lab fires and explosions occur in the hood. Minimizing chemical volumes will reduce the chances of a small accident escalating into a large one.
  
4. Always work at least 6 inches inside the hood to maximize hood capture efficiency.



## WASTE DISPOSAL

### *BIOLOGICAL / MEDICAL WASTE*

**BIOHAZARDOUS WASTE** is defined as research waste associated with human pathogens or human tissue or fluids.

**MEDICAL WASTE** includes biohazardous and sharps waste which is generated or produced as a result of any of the following actions:

- (A) Diagnosis, treatment, or immunization of human beings or animals.
- (B) Research pertaining to the activities specified in subparagraph (A).
- (C) The production or testing of biologicals, i.e. medicinal preparations made from living organisms and their products, including, but not limited to, serums, vaccines, antigens, and anti-toxins.

- The definition of medical waste is from the **California Medical Waste Management Act of 1990**, California Health and Safety Code Section 117690.

All wastes that are classified as medical waste must be stored, handled, transported and treated in accordance with the Medical Waste Management Act, and as detailed by the lab's Biological Use Authorization.

Researchers generating medical waste must attend training on the bloodborne pathogens standards. Contact the campus biosafety officer at x8894.

### **LABORATORY GLASS**

Any item that could puncture regular waste bags and endanger waste handlers (e.g. Pipettes). DO NOT pick up broken glass with your hands, if possible. Wear cut-resistance gloves and use a broom. Collect broken glass as carefully and completely as possible. If this is medical waste as described above, place into a hard walled sharps container (red with biohazard label), treat, remove biohazard label, and dispose as solid waste.

### **BIOLOGICAL WASTE (Cell Cultures, etc.)**

Any material that once contained or now contains living organisms, or that is a product, portion, or waste of a living or once-living organism.

- Liquids or semiliquids are treated with a chemical biocide appropriate to the organism. Drain dispose after 30 minutes contact time.
- Solid wastes are treated in an autoclave per operating instructions, then rebagged in an ordinary garbage bag for disposal as solid waste.

### **BLOOD AND BODY FLUIDS:**

#### **Liquid waste:**

- Treat fluids with bleach (10% final volume) and pour into a sink drain connected to the campus sewage system. DO NOT pour into a storm drain.
- Do not store liquid waste for longer than one week

#### **Solid waste:**

- Decontaminate solid and sharps medical waste via steam sterilization.

## UCSB Department of Chemistry and Biochemistry

- Do not autoclave bleach. Bleach is corrosive to autoclave seals and gaskets. It is okay to deliver contaminated items to the autoclave by swaddling it in a bleach covered cloth.
- Add 50-100 ml of water to each bag
- Seal bags or containers with heat sensitive indicator tape
- Limit ~20lbs per bag so that they do not burst open
- Verify that the autoclave runs at a minimum temperature of 121°C and 15 psi for 30 minutes
- Log autoclave runs as part of the autoclave monitoring program by initialing and dating the autoclave receipt or chart paper
- Contain bags in a secondary bin until disposed of in garbage can
- Take bags down to the dumpster if garbage cans are full

**SHARPS MEDICAL WASTE** includes needles, scalpel blades, glass pipettes, slides, cover slips, broken glassware that is *contaminated with blood or OPIM*

### Contaminated Sharps Collection

#### Container Requirements:

- Rigid
- Leak proof
- Puncture resistant
- Sealable lid
- Labeled with the biohazard symbol

#### Container Use Guidelines:

- Do not exceed the fill line at 2/3 full
- Close container lid when not in use
- Store container until the sharps reach the posted fill line
- Door to lab must have a sign indicating presence of sharps medical waste
- Reusing sharps waste containers is not an option

#### Contaminated Sharps Disposal

As of December 2011, at UC Santa Barbara, biohazardous sharps containers are disposed of by the following steps:

1. Seal the container lid
2. Autoclave
3. Deface biohazard symbols
4. Deposit container into the dumpster outside the building

## WASTE DISPOSAL

### CHEMICAL WASTE

#### REGULATIONS

Hazardous waste regulations are stringent and penalties for violations can be severe. Santa Barbara County inspects UCSB labs for compliance on a regular basis.

#### STORAGE

- Store chemical waste in a designated area.
- Label area as, "**HAZARDOUS WASTE STORAGE AREA**"
- Store chemicals in containers compatible with, and durable enough for, the waste.
- Liquid waste must be in screw top containers. Do not overfill container, allow for expansion.
- Gas cylinders and lecture bottles must have regulators removed.

#### LABELING

- Identify waste by proper chemical name (no abbreviations or chemical structures).
- List chemical names of hazardous components in that mixture by percent weight.
- Deface existing labels when reusing containers.
- Label and date container(s) when the first drop of waste is added. Hazardous waste shall be disposed within **9 months** of start date.
- Use **UCSB HAZARDOUS WASTE** label on all hazardous waste containers. All portions of the label must be completed.
- Labels are available for free in all science storerooms.

**SEGREGATION:** group waste into the following categories:

- halogenated organics (*dichloromethane, chloroform*)
- non-halogenated organics (*acetone, methanol, ethanol, xylene*)
- acids with pH 2 or less (*HCL, sulfuric acid*)
- alkaline solutions of pH 12.5 or greater (*sodium hydroxide*)
- alkali metals and other water reactives (*sodium, acetyl chloride*)
- heavy metal solutions and salts (*mercury, silver, zinc*)
- strong oxidizers (*nitric acid, chlorates, permanganates*)
- peroxide-forming chemicals (*dioxane, THF*)
- cyanides (*potassium cyanide, hydrogen cyanide*)
- chemical carcinogens (*acrylonitrile, inorganic arsenic*)
- unstable chemicals
- other toxic chemicals

*CHEMICAL WASTE...CONTINUED*

**DISPOSAL**

- Chemicals may not be disposed in regular trash, sink disposal, or allowed to evaporate.
- Complete a UCSB Waste Pick-up Request Form. Send either by campus mail or fax (X7259). Also available on EH&S website <http://ehs.ucsb.edu> for electronic submission.
- EH&S cannot accept responsibility for improperly labeled, packaged, and/or segregated chemicals, and will not pick them up.
- Transferring waste into appropriate containers is the generators responsibility.
- Waste containers become the property of EH&S and will not be returned.
- Before working with hazardous material attend EH&S Lab Safety course, call X4899 for next available training date.

**CHEMICAL SPILL**

Clean up a spill if you have the proper equipment and feel comfortable doing so. Otherwise, contact EH&S **24-hour line x3194**.

**SAMPLE UCSB HAZARDOUS WASTE LABEL**

<i>University of California at Santa Barbara</i> <i>Santa Barbara, California 93106</i>	
<b>UCSB HAZARDOUS WASTE</b>	
Waste must be segregated, labeled and packaged according to the Campus Hazardous Waste Disposal Procedures.	
Contact Name _____ Department: _____ Phone _____	Start Date: _____
Proper Chemical Name(s): _____	
Additional Content Information: _____	
Physical State: <input type="checkbox"/> Liquid <input type="checkbox"/> Solid <input type="checkbox"/> Gas	
Chemical Hazard Classification:	
<input type="checkbox"/> Flammable <input type="checkbox"/> Oxidizer <input type="checkbox"/> Corrosive <input type="checkbox"/> Reactive <input type="checkbox"/> Toxic/Poison	
<i>In case of an emergency contact UCSB-EH&amp;S at x3194</i>	

## WASTE DISPOSAL

### SHARPS AND GLASS DISPOSAL

Sharps are defined as any object having acute corners, edges or protuberances capable of cutting or piercing. In other words, needles, razor blades, broken glass, etc. such items are routinely generated in laboratories and need to be properly disposed. Given their capacity to injure the custodial staff and others, these items cannot be disposed of in the normal lab trash. The following guidelines must be followed:

#### Uncontaminated broken glass and Pasteur pipettes

These items should be placed into a labeled “**Glass Only**” trash box or other sturdy container. Cardboard boxes specifically made and labeled for this purpose are available from scientific supply companies, or perhaps in your departmental storeroom. When nearly full, dispose of contents into the trash dumpster for your building.

#### Hypodermic needles, Syringes, Scalpels, etc.

##### General Practices:

- Label a rigid puncture-proof container with the words “**sharps waste**” (note: cardboard is not acceptable)
- Place all sharps waste into sharps container as they are generated
- Tape closed or tightly lid full sharps containers prior to disposal
- Place sealed sharps containers in appropriate receptacle (see below)

##### Specific Disposal Practices:

- Non-contaminated - Containers may be put into regular trash
- Hazardous materials - Containers should be properly labeled as, “**sharps contaminated with (chemical name)**”
- Radioactive materials- Containers should be properly labeled as “**sharps contaminated with (isotope name)**”. Place sealed container in a solid radioactive waste container.
- Biohazardous materials- Sharps contaminated by biohazardous materials must be placed in approved red plastic sharps container (available in Biological Sciences Storeroom). The sealed containers must be autoclaved before disposal. Place autoclaved container in an opaque bag and then place in regular trash.



Example of a Sharps Waste Container



Example of a Glass Waste Container