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Laboratory Safety Manual and Chemical Hygiene Plan

MRL Polymer Characterization Facility

Manual Purpose: - this manual serves two basic purposes:

1. It is the basic laboratory safety manual for UCSB

2. Serves as the campus **Chemical Hygiene Plan (CHP***)* as required by the *California Occupational Safety and Health Administration (Cal-OSHA)*. In short, OSHA requires that a written chemical safety plan address the policies and procedures that an employer has in place to minimize the exposure of its lab employees to chemicals. Workers are required to receive documented training on their CHP. A full summary of the OSHA standard is in Sec. III.

Manual Structure:

Section I: Introduction and Lab-specific Chemical Hygiene Plan (this document). Forms and templates for customizing your CHP with SOPs and other local information. Links to other lab safety programs.

Section II: UC & UCSB policies, procedures and resources. Summaries of key/core lab safety issues that apply to most/all laboratories. Primarily based on specific OSHA requirements.

Section III: Appendices. Includes further information on PI responsibilities, laboratory inspections, and the GHS classification system, as well as a list of particularly hazardous substances.

UC SANTA BARBARA

Laboratory Safety Manual and Chemical Hygiene Plan

MRL Polymer Characterization Facility

Section I: Laboratory-Specific Chemical Hygiene Plan: Standard Operating Procedures

Introduction:

Welcome to the MRL Polymer Facility. Everyone working here has to act in a professional, safe, and environmentally responsible fashion otherwise it becomes difficult for anyone to get any work done. Nobody wants to have to clean up someone else's mess before they can begin work, so everyone needs to take care for the lab. We all need to make sure we all follow the many laws and regulations about safe work practices.

Safety training begins with the EH&S Laboratory Safety class. Everyone working in the lab is required to take this course BEFORE beginning lab work. Most people will need to take the class in person. Additional training builds on the EH&S class. See the section on Required Training.

The second part of the required safety training is this Chemical Hygiene Plan (CHP). Everyone who wishes to work in the Polymer Facility needs to read this Chemical Hygiene Plan. After reading the CHP, people need to document that they have read it. This should be documented by signing the Google Form MRL Polymer Facility Chemical Hygiene Plan User Agreement (UCSB), which I will send to you. The link can also be found in this document.

Please remember that although the work that you may be doing is not particularly hazardous, hazardous procedures may be going on around you. Due to this, we must follow safety guidelines and wear the proper PPE for the environment we are working in.

I try as hard as I can to ensure that the lab is fully functional, as user friendly as possible, and as safe as possible. To accomplish this, I need your help. If you see any kind of safety problem, or if we are low or out of some necessary supply, or that some equipment is not working right, please send me e-mail describing the problem. E-mail is the best way to keep me up to date and to help me remember. Please let me know if there is any imminent hazard and any kind of safety problem. Never leave lab supplies, personal effects, glassware, books, or papers out in the lab except when you are actually using them.

Chemical storage space is very limited. Before purchasing new chemicals please check the laboratory's inventory. Besides conserving room, this will save you time and money. If you have a reagent that someone else needs, please share it with them.

From time to time we have to clean the lab. These may occur when the lab has become particularly messy, before an inspection or a tour, or at the end of the summer intern session. Everyone working in the lab should participate. With everyone's help, we will continue to perform safe and ground-breaking research at one of the top materials research facilities in the world.

Required Training:

In order to become an authorized user of the Polymer Facility, the individual must fulfill ALL the requirements listed below

1. Complete EH&S general laboratory safety training
2. Review MRL general safety documents
3. Be trained to operate the instruments in a safe manner
4. Review the laboratory specific Chemical Hygiene Plan (this document)
5. Document all above steps and submit records to appropriate personnel

Safety training begins with the UCSB EH&S "UC Lab Safety Fundamentals". Everyone working in the lab is required to take this course before beginning lab work. The EH&S Lab Safety class is offered online and in-Person twice quarterly. The online course and the in-person schedule are posted at: http://learningcenter.ucsb.edu

After the EH&S Lab Safety course, people working in the MRL Polymer Lab need to read:

1. MRL Safety Information: https://www.mrl.ucsb.edu/information-safety/mrl-safety/campus-emergency-information
2. The Polymer Laboratory Chemical Hygiene Plan (CHP) paper copy or online. If you have any questions, please contact Dr. Rachel Behrens, MRL 2003, phone: x5850 and e- mail: rachel@mrl.ucsb.edu.
3. To document the completion of this training step, please fill out the form below: http://www.mrl.ucsb.edu/sites/default/files/mrl_docs/forms/safety_training_form.pdf

Instrument training can be arranged by requesting training through the Facilities Billing Services (FBS: https://ucsb.fbs.io/Anon/Logon.aspx) or by emailing the technical director. This training will cover hands-on training to operate the instruments and introduction to the safety information of the laboratory.

As much as it may seem, all of the above is just the foundation of the laboratory safety training. Everyone working in the lab must do the appropriate inquiry, literature research, and thought to ensure that the specific lab work they do is performed safely. The actual preparation will vary depending on what the project will be, but will certainly include studying the chemical hazards of the materials to be used and speaking with people who have done similar work. More work may be necessary, such as reviewing any physical or electrical hazards and considering if specialized personal protective equipment is required. I am available to answer questions and to help, but you ultimately will be the one carrying out the work, so you will need to be familiar with the potential hazards.

General Laboratory Information:

Laboratory Supervisor (PI): Prof. Christopher Bates, MRL 3101
Laboratory Technical Director (TD): Dr. Rachel Behrens, MRL 2003, phone: x5850
Polymer Lab Assistant: Mr. Cesar Rodriguez, MRL 2222, phone: x5428

Laboratory Location(s) (Building /Rooms): MRL 1043, 1050, 1051, and 1052

Department Information
Department Safety:
Alex Moretto, Laboratory Safety Program Manager, UCSB EH&S, phone: 617.480.6630

Dr. Amanda Strom, MRL 2066F, phone: x7925 (DSR)
Sara Bard, MRL 2066E, phone: x8519 (DSR alternate)
Dr. Rachel Behrens, MRL 2003, phone: x5850 (DSR alternate)

Location of Department Safety Bulletin Board: MRL 2042

Location of Building Emergency Assembly Point: South West corner of Engineering II.

Emergency Information:

As applicable, please provide information regarding emergency procedures and equipment specific to the lab(s) under your control. Where applicable you may just reference the emergency contact information on your lab door placards.

- **Evacuation procedures** (e.g., close fire doors, secure certain equipment, etc.)

Leave the room and the building as quickly as possible. Proceed to the Emergency Assembly area which is north of the MRL Building at the south west corner of Eng. II. If time take valuable personal property.

Earthquake
During an earthquake, you should try to stand in a doorframe until all shaking has stopped and only then evacuate the building. Another option is to seek shelter under a desk.

Fire
If a fire alarm goes off you must leave the building and proceed to the Emergency assembly location (SW corner of Eng II). **Do not use the elevators.**

For reporting a fire, fire alarm pull stations are located on the walls of the main hallways. Per SB County Fire and UCSB campus policy, all fires must be reported to 9-911 immediately even if the fire is out. If a fire extinguisher is used it must be reported as it will need to be replaced.

- **First-aid kit** (e.g., location, contents, maintenance responsibility, etc.) First-aid kits are located in each lab:

MRL 1043: Near the emergency shower and eye wash station
MRL 1050: Located near the hallway exit
MRL 1051: On bookcase by door to hallway
MRL 1052: On desk by balance
It is responsibility of the Lab TD to maintain the first aid kits.

In the Event of an Injury
Per campus policy, all **significant injuries must be documented** with "Create a Claim" by completing an Employee First Report (EFR). This is necessary for potential reimbursement for personal medical costs, or Worker's Compensation Claims. For directions on how to create a claim, visit: https://www.ehs.ucsb.edu/sites/default/files/docs/wc/RSS-IIR-Injury-Illness-Reporting-User-Guide.pdf

Serious Injuries
If the situation is **immediately threatening to life or limb**, get emergency care, e.g. by calling 9-911 from any campus phone. This is preferred to taking an injured person directly to the Goleta Valley Cottage Hospital Emergency Room or Sansum Occupation Medical Clinic, where they may not be seen or treated for a long time if they don't arrive in an ambulance.

Other Injuries
Students – For serious injuries not threatening to life or limb, undergraduates and graduate students who are not "employed" by UCSB, may be treated at Student Health Services.
http://studenthealth.sa.ucsb.edu/contact-us/directions

UCSB Employees – Staff, Faculty, Graduate Student employees, undergraduate employees, Post Doc, and other UCSB employees with serious work related injuries, which are not threatening to life or limb, should use an Urgent Care Facility (that UC has contracted with, such as Goleta Valley Cottage Hospital Emergency Room or Sansum Occupation Medical Clinic) for walk-in treatment.

- **Spill cleanup materials** (e.g., location, contents, maintenance, procedures, etc.)

Chemical spill cleanup kits are kept in 1043 MRL on top of the refrigerator and in 1050 MRL under the cabinet by the FBS log in computer. Please contact technical director if more supplies are needed.

- **Laboratory monitors or alarms** (e.g., operation, response, maintenance, etc.)

There are oxygen level monitors in MRL 1051 and 1052. This is maintained by the technical director.

There are no other lab monitors except for low air flow monitors on the fume hoods. These are to be maintained by campus Physical Facilities.

- ***Other Lab-specific emergency information***

The MRL Emergency Operations Plan: https://www.mrl.ucsb.edu/information-safety/mrl-safety/emergency-

operations-plan

Per campus policy, all significant injuries must be documented via the Employee's First Report (EFP) located at http://ehs.ucop.edu/efr as soon as possible. This is necessary for potential reimbursement for personal medical costs, or Worker's Compensation Claims¸ or in serious cases reporting to Cal-OSHA

Per SB County Fire and campus policy, all fires must be reported to 9-911 immediately – even if the fire is out. This is particularly true if there is use of an extinguisher (must be replaced); an injury; or property damage.

Health and Safety References:

Here is a short list of the title and location of health and safety reference materials (reference books, Safety Data Sheets, experimental protocols, etc.) associated with the lab which employees may use to aid them in their work.

	Reference	Location
1.	Laboratory Safety Program/Chemical Hygiene Plan	online only
2.	Paper Copies of (M)SDS	N/A – online only
3.	Electronic Copies of select (M)SDS	computers in 1043, 1050, 1052, and 1053 MRL
4.	Merck Index	2003 MRL
5.	Handbook of Chemistry and Physics	2003 MRL
6.	Fisher Safety- Safety Products Reference Manual	2003 MRL

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 recommended that all lab workers have ready access to this important reference.

Safety Data Sheets (formerly known as MSDS). Per OSHA, all lab users must know:

a) what an SDS is,
b) SDS relevance to their health and safety,
c) how to readily access them*

These issues are all covered in the EH&S lab safety orientation program.

*Labs are encouraged to maintain hard copies of their own SDS for the hazardous chemicals they routinely use, or at minimum, have this link bookmarked by all individuals in the lab.

General Laboratory and Chemical Safety:

In addition to the guidelines provided below, it is recommended that you go over the Laboratory Safety Self-Checklist in Appendix III. This document is also available on the web at:

https://www.ehs.ucsb.edu/sites/default/files/docs/ls/Lab_Self_InspectionChecklist_web_oct_2023.pdf

General

- No storage of food and drinks in the MRL labs 1043, 1050, 1051, and 1052 which has an extensive list of chemicals.
- Smoking is prohibited anywhere in the lab.
- Do not block lab aisles with chairs, stools, or equipment.
- Observe all posted signs and instructions.

Electrical Safety

- Do not use damaged electrical cords. Do not chain extension cords/ power strips.
- Do not leave extension outlets or power strips on the floor where it may be flooded.

Gas cylinder handling

- All compressed gas cylinders need to be secured with welded link metal chain on the top and bottom of the cylinder, so they do not fall over in an earthquake.
- When moving a gas cylinder, place the safety cap over the valve before undoing the chains securing the cylinder.
- Use the special dolly for gas cylinders that is kept in the MRL gas cage (across the little parking lot on the ocean side of the building).
- See: Compressed Gas Cylinders

Chemical Safety

- For transport of larger (> 1 L) glass bottles with chemicals, use designated carriers or plastic buckets.
- ***Keep chemicals stored in the appropriate cabinets or designated storage rooms when not in use (NOT IN FUME HOODS).*** Only obtain an amount to keep your test or research going, like a one day/week supply. This will free up lab bench space and, if you do have a spill it will minimize the amount of chemical released. See: Chemical Storage
- Put away all reagents, samples, and personal materials when not in use.
- ***Keep the lids on chemical containers.*** This sounds obvious but it will effectively reduce the possibility of a spill and reduce any fumes released into your lab, and it's the law.
- ***Label all containers.*** Make sure there are no unidentified containers; reagents, samples, drying papers with sample, or crucibles/boats with samples. Label all material by chemical name (Not just initials or formulas).

Cleaning the lab

- See: Housekeeping Guide for Labs
- Properly dispose of old or unwanted chemicals or any unnecessary items.
- Damp wipe all bench-tops until clean and in particular areas near weighing stations.
- Clean up inside fume hoods.

- Look inside all cabinets for leftover waste and any storage hazards.
- Recycle paper and cardboard properly.
- Unused or spare equipment should be stored in a designated storage room/area.
- Equipment or furniture should not block walkways, electrical panels, or emergency eyewash or showers.
- Check emergency egress path is maintained (minimum exit pathway in rooms is 28 inches).
- Verify the lab(s) are clean, organized and anything else required to make lab look professional.
- Check for trip and slip hazards (oil leaks from pumps, electrical cords or hoses across walking path).

Fume Hoods

- Always work with the sash at the level of the arrow sticker and closed when not used. Your hood should be producing a face velocity of 100-120 ft/min. EH&S tests your hood and posts the arrow tickers at the proper sash level.
- Many newer hoods are equipped with the airflow monitor and alarm to warn you if the air velocity is too low. If the alarm engages, lower the sash slightly until the alarm stops. If your alarm sounds consistently this indicates a real problem- call Amanda Strom (ext. 7925) or EH&S (805-893-4899).
- Store the bare minimum of equipment and chemicals in your hood. Excess materials will block the air flow and reduce performance significantly.
- Chemicals should not be stored in the fume hood- most fires and explosions occur in the hood during chemical manipulations.
- Keep the lab windows and doors closed. Draft from open windows and doors can significantly affect your hood's performance.

Disposal of Sharps

- Lab glassware not contaminated by hazardous materials (eq. Pasteur pipettes) can be placed into labeled "Broken Glass" trash box or other sturdy container. When full, dispose of contents into the red sharps bins outside by the trash and recycling dumpsters.
- Sharps contaminated with chemicals should be placed into a sharps container and labeled as "Sharps contaminated with (chemical name)" and sent to EH&S for disposal. (See: Laboratory Sharps Disposal)

Chemical Waste Disposal

- Hazardous waste regulations are stringent and penalties for violations can be severe. Santa Barbara County inspects UCSB labs for compliance on a regular basis.
- 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 must be in screw top containers. Do not overfill container, allow for expansion.
- Labeling- identify waste by proper chemical name.
- Deface existing labels when reusing containers.
- Label and date containers when the first drop of waste is added. Hazardous waste shall be disposed within 9 months. Labels are available in all science storerooms and in the laboratory.
- Chemicals may not be disposed in a regular trash, sink disposal, or allowed to evaporate. (See: Chemical Waste Disposal)

Chemical Spills

- For detailed instructions, please refer to Chemical Spills in Section II of this document
- Clean up a spill using the proper equipment (please use spill kit contents- available in 1043 and 1050 MRL).
- Cal EH&S 24-hour line 805-893-3194 if necessary.

Safe storage of chemicals

- In earthquake-prone areas like Santa Barbara, it is particularly vital that chemicals be stored safely. Use a secondary container (plastic tub) large enough to contain a spill of the largest container).
  - Store or waste using the following criteria: Flammables, Corrosives, Oxidizers, Carcinogens, Water reactive, Toxics, Pyrophorics. (Globally Harmonized System (GHS) Pictograms and their meanings can be found in Section III)
- Acids- store bottles in the acid cabinets, segregate oxidizing acids from organic acids, and flammable materials. (E.g. nitric acid must be stored in a separate bin.)
- Segregate acids from bases, and from active metals such as sodium, etc.
- Segregate acids from chemicals which could generate toxic gases such as sodium cyanide, etc.
- Flammable store in approved storage cabinet. Keep away from any source of ignition (flame, heat or sparks).
- Oxidizers-react violently with organics. Keep away from flammables, from reducing agents, store in a cool, dry place.
- Pyrophoric substances-spontaneously ignite in air. Some organo-aluminum compounds, silane, divided metals, phosphorus yellow. Rigorously exclude air and water from container. Store away from flammables, store in a cool dry place.
- See: Seismic Hazard Reduction

Refrigerators and Freezers

- There are two fridges/freezers in the lab (MRL 1043 and 1050). They are designed for the storage of flammables but are not owned by the Polymer Facilities, so chemical storage for Polymer Facility users should be done so in their own lab space.
- *No food or drink must be stored in any of the fridges in the lab.*
- Minimize the time that this freezer is opened, as moisture from the air rapidly condenses on it.
- See: Refrigerator & Freezers in the Lab

Personal Protective Equipment (PPE)

Pants and Closed-Toe Footwear

- Pants that come down to your ankle and closed-toe footwear must be worn in the lab at all times!
- Clothing/Pants made out of activewear fabric are discouraged, as the solvents used in this lab are designed to dissolve polymer materials

Lab coats

Laboratory coats are required to be worn while working on, or adjacent to, all hazardous chemicals, biological or unsealed radiological materials. It is imperative to consider the nature of the work performed when choosing a lab coat. In general, you must wear a flame-resistant (blue) lab coat when working in the Main MRL Labs, including MRL 1043 and 1050.

- Note that "standard" lab coats are typically made from a polyester/cotton mix and are not suitable for work with flammables.
- Laboratory coats must not be worn outside of a laboratory unless the individual is traveling directly to an adjacent laboratory work area.
- Each person should have their personal lab coat, which they will receive as part of the PPE provided by UCSB to new lab workers. These laboratory coats must be appropriately sized for the individual and be buttoned to their full length. Laboratory coat sleeves must be of a sufficient length to prevent skin exposure while wearing gloves.
- Lab coats must not be cleaned at home nor in public laundry facilities. Rather, a professional cleaning service must be used. Lab coat laundering drop off stations are at the Chemistry Storeroom (CHEM 1432) or Biological Sciences II (first floor, south side). Any clothing that becomes contaminated with hazardous materials must be decontaminated before it leaves the laboratory. If a lab coat is very heavily contaminated, it should be packaged safely and disposed of as hazardous waste.

Gloves

- Protective gloves must be worn while utilizing any hazardous chemical, biological or unsealed radiological material. These gloves must be appropriate for the material being used and conditions under which such use takes place (e.g., extreme cold).
- A glove recycling program has just been initiated to help reduce our environmental impact. There will be specific receptacles in each of the participating labs that are only for *uncontaminated* and powder-free nitrile, latex, and vinyl gloves
  - ***Uncontaminated*** can include light contamination from non-toxic chemicals as long as they are rinsed and mostly dry prior to disposal
  - **DO NOT** include any gloves that should be considered biohazardous or hazardous waste
- Educate yourself as to which chemicals the gloves you are using are resistant and (im)permeable to. You may be unpleasantly surprised. However, there is a tradeoff between chemical resistance of gloves and the dexterity they allow. The increased dexterity offered by thinner gloves may offset their poorer chemical resistance. After all, it is safest not to spill anything in the first place! The latex or nitrile (purple) single- use examination gloves readily available in our lab are a good choice for most powders and for aqueous solutions, as well as simple alcohols (such as methanol, ethanol, and isopropanol) and diethyl ether.
- EH&S has a page with information on gloves, including links to several reference charts with compiled data on chemical resistance of lab gloves at: https://www.ehs.ucsb.edu/programs-services/lab-safety-chemical-hygiene/labsafety-chp/sec2/selecting-proper-gloves

Spills and Exposure to Hazardous Chemicals

For all incidents in which injury has occurred or may be imminent, follow these steps: Emergency procedure

- Administer First Aid as needed
- Warn people in the area
- Evacuate the area if needed
- Notify 9-911
- Notify the Departmental Safety Representative (DSR) or alternate DSR as soon as feasible

Exposure to Chemicals First Aid

If a chemical splashes in someone's eye, rinse with copious amounts of water for a minimum of **10 minutes**. Small burns or splashes with corrosive chemicals on the skin are also flushed with water for five minutes. Use the emergency showers if a person's hair or clothing has caught fire (rolling the person on the floor is another option for extinguishing flames) or in the event of a larger spill of a hazardous chemical on skin or clothing.

Some Best Lab Practices

These make the lab a better place to work for everybody:

- Put your reagents back in the proper storage location at the end of every workday
- Refill squirt bottles when they are nearly empty
- Get new solvent bottles from the storeroom before running out
- Label all your bottles/flasks with proper chemical names. Preferably use pencil on tags, not a marker
- Label all running reactions, especially reactions running overnight
- Scales/Scale areas: Keep the scale and surrounding area clean. After weighing, take all your stuff with you, and completely clean up any spills you made. Put a note on the scale if you need the tare to remain set; only do this if you will return after a short time (< 15 minutes), else record the tare weight.
- Close the regulator on gas tanks once you are done using them
- Don't leave samples, lab supply, personal effects, glassware, books, or papers out in the lab except when you are actually using them
- Wash and put away your glassware everyday
- Before purchasing new chemicals be sure to check if any of the required reagents are available in the lab via the chemical inventory

Leaving Lab

On completion of your work in the Polymer Facility you will need make a way for next person and put your gear back into circulation. Be sure to do following:

- Let the technical director know when you are leaving a few weeks before you leave.
- Dispose any samples that do not need to be archived. Transfer your samples to your supervisor labs.
- Empty out all drawers which you have been using. Any equipment and glassware that has been assigned to you should be back into circulation.
- Any hazardous/chemical waste you have should be labeled and then placed into the waste chemical area.

- Any reagents in your possession should go back to someone in your group.
- Return keys to Sylvia Vogel (MRL 2066G). Let your PI or lab manager know how to reach you.

Ten Commandments of Safety:

- Thou shalt wear thy safety glasses, as with all other personal protective equipment that shall be required.
- Thou shalt chain all of thy gas cylinders securely with chain of welded link. When the earth shall shake, thy chemicals, bookshelves, and heavy goods must not fall down to the earth or upon thy head.
- Thou shalt not store thy chemicals alphabetically, but only compatibles upon compatibles.
- Thou shalt not smoke within the laboratory. Neither shall thou confuse the laboratory with a place of nourishment.
- Thou shalt never dump thy waste chemicals into the drain. Neither shall thou place any sharp waste, including broken glass, razor blades, nor needles, in the regular trash cans inside the laboratory. Thou shalt place all sharp waste into the dumpster or a special container.
- Thou shalt label all of thy chemicals and samples with thy name and the date. Thou shalt never leave unknown and unmarked bottles of chemicals or samples for thy neighbor.
- Thou shalt purchase only the minimum chemicals for thy needs. Thou shalt covet thy neighbor's chemicals and thou shalt share thy chemicals with thy neighbor.
- Thou shalt not have multiple extension cords in series.
- Thou shalt not deliver oxygen in plastic tubing, lest the fires of Hell visit upon thy experiment.
- Thou shalt know what thou are doing and about the hazards thou faceth. Thou shalt never toil in the laboratory until thou hast studied and trained about safe work practices.

Identifying Chemical Hazards

Every lab worker has the responsibility to learn about and understand the hazards of the chemicals they use before starting to use those chemicals. Do not assume that a material is harmless just because you haven't heard otherwise. Many chemicals are harmful, and some chemicals are mostly harmless by themselves but very dangerous in combination with certain other chemicals.

Besides talking to other people in the lab that use these materials (but don't assume that they have done their homework, even if they are senior to you!!), these are some resources:

- Safety Data Sheets (SDS). Widely available online, they are especially useful for mixtures, but also for reagents. SDS were intended to be a one-stop source of chemical hazard information, but they frequently are not very specific, not as succinct as one would like, and make everything sound extremely hazardous because they err on the side of caution e.g. for personal protective measures.
- Laboratory Chemical Safety Summaries (LCSS) are available for far fewer compounds, but more succinct and useful.
- The Merck Index is a compendium that has relevant information for many common chemicals. A copy of the Merck Index is kept in room 2003.

Communicating Safety and other Lab Issues

You should report any procedure, condition or situation that you consider to be unsafe, or potentially unsafe. Except for an actual emergency, the best way to communicate a safety problem is to write an email to the DSR or alternate DSRs, depending on the nature of the problem. Forms for anonymously reporting a hazardous condition or practice (Hazard reporting forms) are available at the MRL Safety Corner bulletin board in room 2042 if you feel that reporting the hazard in the usual manner would jeopardize you in some way. If supplies are missing, a hazardous waste pickup needs to be arranged, or a piece of equipment is not working, contact the technical director.

Background: Standard Operating Procedures

Per Cal/OHA regulations, a Chemical Hygiene Plan must include Standard Operating Procedures (SOPs) that pertain to the storage and use of the hazardous chemicals in your laboratory. The following steps should be followed in order to complete this requirement.

1. **Determine which SOPs you need:** Compare your chemical inventory and lab processes against the UCSB Standard Operating Procedures library. There, SOP templates are available for most hazard classes, a number of specific chemicals, and certain laboratory processes. Additionally, a blank SOP template is available. If you require an SOP template that is not available in the library, feel free to contact EH&S for assistance.
2. **Customize the SOP templates you selected:** Sections in red on the template must be filled out to reflect the details specific to your research group. Specifically, the *Laboratory Specific Information* section must be filled out to generate a Cal/OSHA compliant SOP. This can be very detailed if so desired, but in many cases, this can be satisfied by just a few sentences.
3. **Add completed SOPs to the end of this document.**
4. **PI completes the Certification Page below**
5. **Laboratory workers review the SOPs, as well as the UCSB Chemical Hygiene Plan, and sign off on the Laboratory Worker Training Record page below.**

Standard Operating Procedure Library Certification Page

PI/Laboratory Supervisor Name:

Applicable Laboratory Locations (Building, Room #):

PI/Laboratory Supervisor Signature:

I certify that I have reviewed and approve the attached Laboratory Specific Chemical Hygiene Plan with Standard Operating Procedures for laboratory operations being conducted in the locations noted above.

Signature:_____

Laboratory Worker Training Record:

UCSB Chemical Hygiene Plan and Laboratory Specific Chemical Hygiene Plan with Standard Operating Procedures

PI/Laboratory Supervisor:_____

The following laboratory workers have reviewed and understand the contents of the UCSB Chemical Hygiene Plan and this laboratory's Laboratory Specific Chemical Hygiene Plan with Standard Operating Procedures:

Name (Please print)	**Signature**	**Date**

Standard Operating Procedure General Information

The following apply to all chemicals unless specifically noted in the customized SOP. Any additional requirements will also be noted in the SOP:

Engineering Controls:

Fume Hood: All chemicals should be transferred and used in an annually certified chemical fume hood, in an effort to keep exposures as low as possible. If your specific protocol does not permit the handling of certain chemicals in a fume hood, contact EH&S to determine whether additional *respiratory protection* and/or *specialized local ventilation* is warranted.

Safety Shielding: Shielding is required of there is significant risk of explosion, implosion or splash. This risk can be due to the nature of the chemicals involved, the reaction conditions (temperature, pressure) or scale.

Storage: All chemicals should be stored upright, tightly sealed, and in a cool, dry, and well-ventilated space. Segregate incompatible materials from each other based on information from the SDS and as described in the Chemical Hygiene Plan. All containers must be labeled in English with the name of the material (no formulas or acronyms) and all relevant hazard statements (e.g. corrosive, flammable, etc.)

First Aid and Emergencies:

Fire: DO NOT use water to put out a fire. A class ABC fire extinguisher can be used to extinguish most laboratory fires. If pyrophoric or water reactive metals are involved in the fire, use a class D extinguisher.

Spills: Evacuate the location where the spill occurred. Notify others in the areas of the spill, including your supervisor. Notify EH&S in case of personal exposure. If the spill is <1 Liter and of a known material of limited toxicity, flammability and volatility, post someone just outside of the spill area, don proper PPE, and clean the spill following the procedure in the Chemical Hygiene Plan Chapter 4 and the UCSB Emergency Flip Chart. Otherwise, call EH&S at X3194, or 911 if there is immediate danger to life, health or property.

Exposures:

Skin or eye contact: Remove contaminated clothing and accessories. Flush affected area with water for 15 minutes. If symptoms persist, get medical attention.

Inhalation: Move person to fresh air. If symptoms persist, get medical attention.

Ingestion: Rinse mouth with water. If symptoms persist, get medical attention.

Decontamination: Wear proper PPE, decontaminate equipment and benchtops using soap and water. Dispose of contaminated paper towels as hazardous waste, following the UCSB hazardous waste procedures described in the UCSB Chemical Hygiene Plan.

Waste Disposal: Refer to Section II, Chapter 3 of the UCSB Chemical Hygiene Plan.

Polymer Facility Specific Standard Operating Procedures Following This Page.

These documents are addendums to the UC Santa Barbara Chemical Hygiene Plan, and covers additional information on the safe handling and storage of the materials described beyond the practices described therein. Users must be familiar with the UC Santa Barbara Chemical Hygiene Plan before utilizing these SOPs. The SOPs included in this CHP may not cover all of the hazardous material used in the Polymer Facility. Please refer to your group's CHP for additional SOPs.

SOPs included in this section:

Standard Operating Procedure

Carcinogens, Reproductive Toxins and Acute Toxins

(Cal/OSHA Particularly Hazardous Substances)

Overview

Three classes of hazardous chemicals are defined by Cal/OSHA as 'Particularly Hazardous Substances' (PHS):

- *Carcinogens* are materials that have the potential to cause cancer.
- *Reproductive Toxins* are materials that affect reproductive capabilities, including *mutagenesis* (causing chromosomal damage), *teratogenesis* (effects on the fetus), and adverse effects on sexual function and fertility.
- *Acute toxins* are substances that may be fatal as a result of a single exposure ($LD_{50} \leq 50$ mg/kg (oral), 200 mg/kg (dermal), 500 ppm (inhaled).

If the carcinogen you are using is a Listed Carcinogen (8 CCR §5209), EH&S will contact you upon your ordering of that material to address safety requirements that go beyond this SOP.

Special Handling and Storage Concerns

Personal Protective Equipment

- Traditional lab coat. Flame resistant if material is flammable.
- Nitrile or Neoprene Gloves are adequate for possible incidental exposure in most cases. Consult a glove chart if the specific material in use is particularly hazardous, or if the risk of contact is high.
- ANSI Z87.1-compliant safety glasses. Safety goggles if a splash hazard is present.

Special Storage Requirements

Store Particularly Hazardous Substances away from other chemicals. Each container must include all applicable hazard warnings. It is recommended that the appropriate GHS pictogram also be on the container. The storage area must be within a PHS designated area, and all containers stored in secondary containment.

Engineering Controls

Fume Hood: All PHS *must* be handled in a fume hood. If this is not possible due to scale or equipment, contact EH&S to determine alternate ventilation approaches or respiratory protection needs.

Special Handling Considerations

Only use PHS in a designated area. This designated area may be the entire laboratory, or only a portion of it. Note that the information in this SOP describes the baseline requirements for PHS. You will need to generate or review a chemical-specific SOP if the material you are handling has:

- *Unique properties*: e.g. cyanide salts, where the risk of exposure varies greatly with pH.
- *Multiple hazards*: e.g. azide salts, which are highly toxic and potentially explosive.
- *Extreme hazards*: e.g. methyl mercury, which penetrates the skin and is lethal in tiny doses.

Decontamination

This SOP covers a wide range of materials. Consult the SDS for any possible special decontamination procedures.

Waste Management

Note that some PHS waste may be considered *Extremely Hazardous Waste* and should be handled as described in the UC Santa Barbara Chemical Hygiene Plan. This includes disposing of the emptied original container as hazardous waste through EH&S.

First Aid and Emergencies

Spill

Treat all spills of these materials as a major spill. Do not attempt to clean up the spill yourself. Notify others in the area of the spill, including your supervisor. Evacuate the area and call 911. Remain on-site at a safe distance to provide detailed response to first responders. Report any exposures to EH&S.

Fire

Standard measures apply.

Personnel Exposure

Skin or eye contact: Remove contaminated attire. Flush affected area with water for 15 minutes. If symptoms persist, get medical attention.

Inhalation: Move person to fresh air. Get medical attention immediately.

Ingestion: Rinse mouth with water. Get medical attention immediately.

Laboratory Specific Information

Prior Approval Required

- ☒ **NO**
- ☐ **YES (describe):**

Designated Area (required for Particularly Hazardous Substances)

- ☐ **Entire Laboratory Area**
- ☒ **Other (describe): MRL 1043, MRL 1050**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: 1 atm
Scale Range: 1-4L

Other Relevant Details: Specific Chemicals used: Chloroform, Dichloromethane, Methanol

Standard Operating Procedure

Dichloromethane

(Methylene Chloride)

Overview

Dichloromethane is an anesthetic. Inhaling the vapor can cause light-headedness leading to unconsciousness and even death. Other symptoms of exposure include skin, eye and respiratory tract irritation. Strong evidence supports that dichloromethane is a human carcinogen upon chronic exposure. Its high volatility makes it imperative that it be handled in a fume hood or other vapor-capturing device. Unlike many organic solvents, dichloromethane is not flammable. Dichloromethane is considered a Particularly Hazardous Substance (PHS). It is also tightly regulated by EPA under 40 CFR part 751 Subpart B, as described in the UC Santa Barbara Chemical Hygiene Plan, and therefore requires an Exposure Control Plan (ECP). Completion of this SOP template fulfills this requirement.

Substitution

Per EPA regulations, substitution of dichloromethane for other less hazardous solvents must be considered before use:

The following substitutes have been considered for dichloromethane:

- ☐ 2-Methyltetrahydrofuran
- ☐ Cyclopentylmethyl ether
- ☐ Methyl tert-butyl ether
- ☐ Methyl isobutyl ketone
- ☐ Toluene
- ☐ Ethyl acetate
- ☐ Methanol
- ☐ Ethanol
- ☐ Isopropanol
- ☐ Other _____

They have been deemed inadequate for the following reason(s):

- ☐ Undesirable cross-reactivity
- ☐ Poor match for polarity
- ☐ Poor match for density
- ☐ Boiling point too high
- ☐ Need to maintain reproducibility of established procedure
- ☐ Other _____

Special Handling and Storage Concerns

Personal Protective Equipment

Dichloromethane may only be handled while wearing the following PPE:

- ☐ Eye Protection
  - ☐ Safely glasses (ANSI Z87.1-compliant)
  - ☐ Goggles
  - ☐ Face shield
  - ☐ Other _____
- ☐ Skin Protection
  - ☐ Lab coat
  - ☐ Apron
  - ☐ Other _____
- ☐ Hand Protection
  - ☐ Nitrile gloves (Double gloved)
  - ☐ Polyvinyl alcohol gloves
  - ☐ LLDPE gloves
  - ☐ Viton gloves
  - ☐ Silvershield gloves

- Butyl, Viton and polyvinyl alcohol gloves are recommended. Standard nitrile and neoprene lab gloves are NOT recommended but can be used if double gloved.

Special Storage Requirements

Dichloromethane is a PHS. Each container must include all applicable hazard warnings. It is recommended that the appropriate GHS pictograms also be on the container. The storage area must be within a PHS designated area, and all containers stored in secondary containment.

Engineering Controls

Dichloromethane will be used with the following engineering controls in place:

- ☐ Local Exhaust Ventilation (select one)
  - ☒ Fume hood
  - ☐ Glove box
  - ☐ Exhausted enclosure
  - ☐ Snorkel
- ☐ Splash shield
- ☐ Other _____
- ☐ Mandatory Exposure monitoring has been conducted by EH&S. Date _____

Fume Hood: Dichloromethane *must* be handled in a fume hood. If this is not possible due to scale or equipment, contact EH&S to determine alternate ventilation/isolation approaches or respiratory protection needs.

Special Handling Considerations
Only use dichloromethane in a PHS in a designated area. This designated area may be the entire laboratory, or only a portion of it.

Decontamination
Standard decontamination procedures apply. Use great caution in avoiding exposure.

Waste Management
Standard waste disposal procedures apply.

First Aid and Emergencies

Spill
Treat all spills of benzene as major spills. Do not attempt to clean up the spill yourself. Notify others in the area of the spill, including your supervisor. Evacuate the area and call 911. Remain on-site at a safe distance to provide detailed response to first responders. Report any exposures to EH&S.

Fire
Dichloromethane is not itself flammable. Standard firefighting measures apply

Personnel Exposure
Skin or eye contact: Remove contaminated attire. Flush affected area with water for 15 minutes. If symptoms persist, get medical attention.
Inhalation: Move person to fresh air. Consult a physician is symptoms persist.
Ingestion: DO NOT induce vomiting. Rinse mouth with water. Consult a physician.

Laboratory Specific Information
Prior Approval Required

- ☐ **NO**
- ☒ **YES (describe):**

Pre-Approval by the Principal Investigator is required before use of dichloromethane. Do not use dichloromethane until you have obtained the necessary preapproval.

All occupants of MRL 1043 and 1050 shall review this SOP/ECP as well as the UC Santa Barbara Chemical Hygiene Plan prior to entry and sign that they have received the information they contain and agree to abide by the training provided to them.

Dichloromethane is approved for use in MRL 1043 and 1050 in fume hoods.

Dichloromethane is approved for storage in MRL 1043 and 1050 in lab solvent storage cabinets.

Stop all use of dichloromethane if any malfunction of the local exhaust ventilation device indicated above is suspected and contact EHS.

Designated Area

- ☐ **Entire Laboratory Area**
- ☒ **Other (describe): MRL 1043, MRL 1050**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: 1 atm
Scale Range: <1L

Other Relevant Details:

Standard Operating Procedure

Peroxide-Forming Chemicals

Overview

Peroxide-Forming chemicals are flammable organic liquids which are capable of forming potentially explosive organic peroxides (R-O-O-R') upon exposure to air or other oxidizing impurities. Organic peroxides are among the most hazardous substances handled in the laboratory. They are sensitive to oxygen, heat, friction, light, strong oxidizers and reducing agents, and are far more shock sensitive than most primary explosives such as TNT. It is particularly dangerous to allow these materials to evaporate to dryness, such as during distillation. **ETHERS** are the peroxide-formers most common in the laboratory.

Special Handling and Storage Concerns

Personal Protective Equipment

- Flame Resistant Lab Coat.
- Nitrile or Chloroprene gloves are adequate for incidental exposure. Consult a glove chart if large splashes or immersion are possible.
- ANSI Z87.1-compliant safety glasses. Safety goggles if a large splash hazard is present.

Special Storage Requirements

Store in airtight containers, and in a flammable storage cabinet or refrigerator rated for flammable materials. Containers larger than 4 L are not recommended, due to the time-sensitivity of these materials. *Date containers upon receipt and opening*. As noted in the UC Santa Barbara Chemical Hygiene Plan:

- Class A peroxide formers must be discarded within 3 months of receipt or formation:
  (Divinyl ether, divinyl acetylene, isopropyl ether, sodium and potassium amide, potassium metal.)
- Class B peroxide formers must be discarded 6 months after opening, 12 months if they contain an inhibitor:
  (Diethyl ether, Furan, tetrahydrofuran, dioxane, etc.)
- Class C peroxide formers must be discarded after 5 days, 12 months if they contain an inhibitor:
  (Acrylic acid, ethyl acrylate, methyl methacrylate, styrene, vinyl acetate, vinyl chloride, vinyl pyridine)

Engineering Controls

Diethyl ether must be used in a fume hood at all times. Solvent mixtures for purification equipment that contain tetrahydrofuran or other higher boiling ethereal solvents must be prepared in the fume hood, but can be used in equipment outside the hood as long as the reservoir container is sealed.

Special Handling Considerations

Static Electricity Risk: Large containers of peroxide-forming chemicals are discouraged due to the time-sensitivity of these materials. If metal drums are used (≥20 L), they should always be grounded, and they should be bonded to the receiving container during transfer. Flammable storage cabinets are equipped with a grounding system that should be connected to a building ground. Transferring these materials between unbonded metal containers, or between plastic containers may lead to a fire hazard due to static electricity buildup.

Decontamination

This SOP covers a wide range of materials. Consult the SDS for any possible special decontamination procedures.

Laboratory Specific Information

Prior Approval Required

- ☒ **NO**
- ☐ **YES (describe):**

Designated Area

- ☐ **Entire Laboratory Area**
- ☒ **Other (describe): MRL 1043, MRL 1051, MRL 1050**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: 1 atm
Scale Range: 1-4L

Other Relevant Details: Specific Chemical Used: Tetrahydrofuran. Special sticker must be placed upon bottle on arrival and received date noted. Opened date must also be recorded on sticker.

Standard Operating Procedure

Flammables

Overview

A flammable solvent is defined by the National Fire Protection Agency (NFPA) as having a flashpoint below 100 °F (37.8 °C). The lower the flashpoint, the more easily the liquid can be ignited. Their presence in the laboratory in fairy large volumes greatly exacerbates the fire risk posed by these materials. The large volumes also increase the risk posed by any other hazards associated with the specific material (toxicity, carcinogenicity, etc.)

Special Handling and Storage Concerns

Personal Protective Equipment

- Flame Resistant Lab Coat.
- Nitrile or Neoprene Gloves are adequate for possible incidental exposure. Consult a glove chart if large splashes or immersion are possible.
- ANSI Z87.1-compliant safety glasses. Safety goggles if a large splash hazard is present.

Special Storage Requirements

Store in a flammable storage cabinet with self-closing hinges, or in a refrigerator rated for flammable storage. Any container larger than 1 gallon (4L) must be stored in a flammable storage cabinet at all times. *The maximum amount of flammable material allowed outside of these storage areas is 10 gallons*. Store flammable materials away from oxidizers and combustible materials. Flammable cabinets must be labeled clearly with the statement "Flammable – Keep Fire Away".

Engineering Controls

If your protocol does not permit the handling of these materials in a **fume hood**, EH&S *must* be contacted to assess alternate ventilation options.

Special Handling Considerations

Static Electricity Risk: Large containers of flammable liquid ($\geq$ 20L) should always be grounded, and should be bonded to the receiving container during transfer. Flammable storage cabinets are equipped with a grounding system that should be connected to a building ground. Transferring these materials between unbonded metal containers, or between plastic containers may lead to a fire hazard due to static electricity buildup.

Decontamination

This SOP covers a wide range of materials. Consult the SDS for any possible special decontamination procedures.

Waste Management

Segregate halogenated from non-halogenated organic solvent waste.

First Aid and Emergencies

Spill

A number of organic solvents are carcinogenic (e.g. benzene, methylene chloride, formaldehyde). Do not attempt to clean up a spill of these materials. Consult the SDS to confirm toxicity information, then call

EH&S for assistance.

Fire

Standard firefighting measures apply.

Personnel Exposure

Standard measures apply.

Laboratory Specific Information

Prior Approval Required

- ☒ **NO**
- ☐ **YES (describe):**

Designated Area

- ☐ **Entire Laboratory Area**
- ☒ **Other (describe): MRL 1043**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: 1 atm
Scale Range: <4L

Other Relevant Details:

Standard Operating Procedure

Corrosives

Overview

Corrosives are materials, acids and bases, that cause the destruction of exposed tissues and mucous membranes. Rapid damage can occur to eyes and skin, as well as to the respiratory tract (inhalation) and gastrointestinal tract (ingestion). Strong corrosive solutions have a pH <2.5 (strong acids) or >11 (strong bases) and cause damage via the reaction of hydroxide ions (OH^-) or hydronium ions (H_3O^+) with tissue. *This SOP <u>does not</u> cover oxidizing acids (e.g. Nitric acid, perchloric acid), or corrosives with other highly hazardous properties (e.g. hydrofluoric acid). If using, please see the SOP specific to these materials.*

Special Handling and Storage Concerns

Personal Protective Equipment

- Traditional white lab coat. Chemical-resistant apron when working with large volumes.
- Nitrile or neoprene gloves are adequate for possible incidental exposure. Consult a glove chart if large splashes are possible. *No latex gloves!*
- ANSI Z87.1-compliant safety glasses. Safety goggles or safety goggles plus face shield if a large splash hazard is present.

Special Storage Requirements

Acids and bases must be segregated in storage. Store in chemically-resistant secondary containers (e.g. polypropylene tubs). Store below eye level. Segregate from active metals such as sodium, potassium, magnesium, etc. Use a corrosives storage cabinet if available.

Engineering Controls

If your protocol does not permit the handling of these materials in a fume hood, assess the volatility of the material (e.g. hydrochloric acid) and contact EH&S if alternative ventilation options are necessary.
An eye wash/safety shower unit *must* be within a 10 second walk (about 35 feet) from where corrosives are being handled, with only a single intervening door, opening in the direction of travel.

Special Handling Considerations

When forming solutions/dilutions, to avoid serious splatter risk ***add the corrosive to water, and never the reverse***.
Acids can react with metals, releasing flammable hydrogen gas.

Waste Management

Segregate acids of pH $\leq$2, bases of pH $\geq$12.5, and oxidizing acids.

First Aid and Emergencies

Spill

It is best practice to keep acid and base neutralizers in the laboratory spill kit if corrosives are used (e.g. sodium bicarbonate, citric acid).

Personnel Exposure

Standard measures apply. Pay extra attention to flushing affected skin/eyes with water for a full 15 minutes using an eyewash/safety shower unit.

Laboratory Specific Information

Prior Approval Required

- ☒ **NO**
- ☐ **YES (describe):**

Designated Area

- ☐ **Entire Laboratory Area**
- ☒ **Other (describe): MRL 1043, MRL 1051**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: 1 atm
Scale Range: <1L

Other Relevant Details: Chemical specifically used: 0.1% solution of formic acid

Standard Operating Procedure

Nitric Acid



Overview

Nitric acid is an extremely corrosive acid and **strong oxidizing agent**. It may be harmful if ingested, inhaled, or absorbed through the skin. It can cause severe skin and eye burns resulting in irreversible damage. It is extremely destructive to the tissue of the mucous membranes and the upper respiratory tract.

As a strong oxidizing agent, it can cause **violent explosions** when combined with reducing agents such as organic solvents and reagents. Therefore great care must be taken to store it separately from organic acids, flammable and combustible liquids (such as organic solvents), and organic reagents in general. Nitric acid waste must also be segregated from all other organic waste. **Combination of nitric acid waste with other non-compatible waste streams is a major cause of laboratory explosions**.

Special Handling and Storage Concerns

Personal Protective Equipment

- Traditional white lab coat. Chemical resistant apron when working with large volumes.
- Nitrile or neoprene gloves are adequate for possible incidental exposure. Viton gloves if large splashes are possible. *No latex gloves!*
- ANSI Z87.1-compliant safety glasses. Safety goggles or safety goggles plus face shield if a large splash hazard is present.

Special Storage Requirements

Store separately from other laboratory chemicals with which it may react. For oxidizing acids such as nitric acid this includes all organic materials including organic acids, reducing agents, bases, alkali metals, cyanides, and powdered metals. Ensure secondary containment is used. Do not store directly on wooden shelves.

Engineering Controls

If your protocol does not permit the handling of these materials in a fume hood, assess the volatility of the material (e.g. hydrochloric acid) and contact EH&S if alternative ventilation options are necessary.
An eye wash/safety shower unit *must* be within a 10 second walk (about 35 feet) from where corrosives are being handled, with only a single intervening door, opening in the direction of travel.

Special Handling Considerations

When forming solutions/dilutions, to avoid serious splatter risk **add the corrosive to water, and never the reverse.**

Waste Management

Nitric acid waste must be segregated from organic or reducing agent waste. Best practice is to store nitric acid containing waste streams in dedicated containers segregated from all other waste streams. Reduce in-lab storage time by selecting small (≤1L) containers that are filled and removed from the laboratory promptly.

Combination of nitric acid waste with other non-compatible waste streams is a major cause of laboratory explosions.

First Aid and Emergencies

Spill
Standard spill procedures apply
Fire
Standard firefighting measures apply.
Personnel Exposure
Standard measures apply.

Laboratory Specific Information

Prior Approval Required

- ☒ **NO**
- ☐ **YES (describe):**

Designated Area

- ☐ **Entire Laboratory Area**
- ☒ **Other (describe): MRL 1043, MRL 1050**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: 1 atm
Scale Range: < 1L

Other Relevant Details: Separate storage required. Please have any waste picked up immediately.

Standard Operating Procedure

Cryogens

Overview

Cryogens are gases that have been liquefied or solidified by extreme cooling. The three common laboratory cryogens are: dry ice (-78.5 °C), liquid nitrogen (-195.79 °C) and liquid helium (-269 °C). Tissues exposed to cryogens can freeze, causing severe frostbite. They expand greatly upon evaporation which creates two hazards: oxygen displacement (asphyxiation risk) and pressurization of sealed or poorly vented containers (explosion risk). Cryogens can embrittle plastic or rubber, and crack glass due to their extremely low temperatures. Liquid nitrogen and helium can condense liquid oxygen out of the air. This powerful oxidizer can cause powerful explosions upon contact with organic materials. For carbon dioxide, the Cal/OSHA Permissible Exposure Limit (PEL: 8 hour time weighted average) = 5,000 ppm, and the Short Term Exposure Limit (STEL: 15 minute time weighted average) = 30,000 ppm.

Special Handling and Storage Concerns

Personal Protective Equipment

- Traditional white lab coat.
- Insulated, impermeable elbow-length cryogenic gloves
- ANSI Z87.1-compliant safety glasses. Safety goggles and face shield if a large splash hazard is present.

Special Storage Requirements

Cryogens should be stored in well-ventilated rooms. Due to their low pressure and protective rings around the valves and regulators, cryogen dewars do not need to be affixed to a permanent structure. Inspect pressure release devices regularly, as ice buildup can plug or otherwise disable them. Never store cryogens in tightly sealed containers, including refrigerators and freezers.

Engineering Controls

Oxygen sensors: May be necessary in rooms where large quantities of cryogens are stored or handled, or in areas with limited ventilation (closets, cold rooms).

Special Handling Considerations

Be cautious when handling cryogens in poorly ventilated areas such as cold rooms.
Avoid condensing liquid oxygen when using liquid nitrogen or helium. Check vacuum systems and other equipment for leaks, and be vigilant in checking for the presence of liquid oxygen, a blueish liquid.
When transporting cryogens on elevators, use service or freight elevators when available. In addition, when transporting cryogens by elevator:

- Post a sign reading “DO NOT ENTER – GAS TRANSPORT” to exclude passengers. Send the elevator to the desired floor, but do not enter the elevator yourself.
- When possible, have someone send the elevator up while another person waits on the receiving floor to take the cylinder out of the elevator. If this is not possible, another plan should be devised to ensure that the cylinder is taken out of the elevator once it reaches the desired floor.

First Aid and Emergencies

Uncontrolled Release

In the event of an uncontrolled release, assume that an oxygen deficient atmosphere is present. Notify others in the area and evacuate the room until adequate oxygen levels can be confirmed.

Personnel Exposure

Move person to fresh air only if safe to do so. *If you suspect that a person has lost consciousness due to oxygen deprivation, call 911 and do not enter the room*. If symptoms persist, seek medical attention. If any tissues appear to have frozen, get medical attention immediately. Apply a dry, sterile bandage. Do not rub the affected area.

Laboratory Specific Information

Prior Approval Required

- ☒ **NO**
- ☐ **YES (describe):**

Designated Area

- ☐ **Entire Laboratory Area**
- ☒ **Other (describe): MRL 1051, MRL 1052**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: 22psi
Scale Range:

Other Relevant Details: Oxygen alarms used in MRL 1051 and 1052

Standard Operating Procedure

Compressed Gases

Overview

Chemicals in this category present hazards based on one or more of these characteristics:

- Pressurization
- Oxidizing ability
- Flammability*
- High Toxicity*

Many compressed gases are also considered to be simple asphyxiants due to their ability to displace oxygen in the event of a rapid release.

***Highly toxic and pyrophoric gases are some of the most dangerous materials found in the laboratory. A gas-specific Standard Operating Procedure must be developed for these materials in conjunction with the campus Chemical Hygiene Officer**.

Special Handling and Storage Concerns

Personal Protective Equipment

- Traditional white lab coat.
- Nitrile or neoprene gloves are adequate for possible incidental exposure.
- ANSI Z87.1-compliant safety glasses.

Special Storage Requirements

Proper mounting of gas cylinders is imperative. Follow all mounting requirements as described in the UC Santa Barbara Chemical Hygiene Plan Chapter 3, section 'Chemical Inventory, Storage and Transport'.
Corrosive gases: Store lecture bottles 6 months or less, cylinders 2 years or less.
Oxidizing gases: Store with 20 feet separation from, or non-combustible partition between, *flammable gases*.

Engineering Controls

Oxygen sensors: May be necessary in rooms where large quantities of compressed gases are stored or handled, or in areas with limited ventilation (closets, cold rooms).
Carbon monoxide sensors: Required for carbon monoxide use if the cylinder or any plumbing are outside of a fume hood or gas cabinet.

Special Handling Considerations

Be cautious when handling compressed gases in poorly ventilated areas such as cold rooms.
Inspect cylinders and valves for corrosion or other damage on a regular basis.
Transport:

- Disconnect regulators and other apparatus prior to transport.
- Always replace the valve safety cap before transporting cylinders.
- Cylinders must always be transported using a hand truck or cart designed for that purpose.
- Transport cylinders upright.

When transporting compressed gases on elevators, use service or freight elevators when available. In addition, when transporting compressed gases by elevator:

- Post a sign reading "DO NOT ENTER – GAS TRANSPORT" to exclude passengers. Send the elevator to the desired floor, but do not enter the elevator yourself.
- When possible, have someone send the elevator up while another person waits on the receiving floor to take the cylinder out of the elevator. If this is not possible, another plan should be devised to ensure that the cylinder is taken out of the elevator once it reaches the desired floor.

First Aid and Emergencies

Uncontrolled Release

In the event of an uncontrolled release, assume that an oxygen deficient atmosphere is present. Notify others in the area and evacuate the room until adequate oxygen levels can be confirmed.

Personnel Exposure

Move person to fresh air only if safe to do so. *If you suspect that a person has lost consciousness due to oxygen deprivation, call 911 and do not enter the room*. If symptoms persist, seek medical attention.

Laboratory Specific Information

Prior Approval Required

☒ **NO**
☐ **YES (describe):**

Designated Area

☒ **Entire Laboratory Area**
☐ **Other (describe):**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: 0psi-2500psi
Scale Range: varies

Other Relevant Details: All cylinders must be secured at top and bottom of cylinder with chains.

Standard Operating Procedure

Vacuum Systems

Overview

Systems under vacuum and their associated equipment have a variety of hazards associated with them, including:

- Implosion and the associated flying debris, splattering chemicals and possibly fire.
- Condensation of liquid oxygen into a cold trap using liquid nitrogen as coolant. Liquid oxygen is an explosion hazard when warmed in a closed system, and when it comes in contact with organic material.
- Pinching extremities or catching clothing in the vacuum pump belt system.
- Exposure to hazardous material due to improper venting of pump exhaust.

These systems are typically quite complicated and require extensive hands-on training prior to use.
Related SOP:

- Cryogens

Special Handling and Storage Concerns

Personal Protective Equipment

ANSI Z87.1-compliant safety glasses or goggles. A face shield is recommended if the system is made of glass or other breakable material, and is not behind a fume hood sash or blast shield.

Engineering Controls

Special Handling Considerations

General Concerns

- Understand the type of vacuum pump being used, and ensure that it is appropriate for the application (e.g. evaporation of solvents vs. high vacuum).
- Prepare for power outages. 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.
- 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.

Traps and Venting

- Mechanical vacuum pumps should be protected by cold traps – generally liquid nitrogen based. Cold traps are dangerous due to their ability to condense liquid oxygen. Therefore, operation of low these traps must be thoroughly understood. Both the cooling and warming phases deserve undivided attention, and the system tested for leaks regularly.
- If hazardous materials are used with the vacuum system they should be located in, and **vented** to, a fume hood.
- Dewar flasks are insulated by being under high vacuum and are therefore subject to implosion. They should be wrapped in tape or plastic sheathing and generally come that way.

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.

Chemical Hazards

- Mechanical pump oil can become contaminated with hazardous materials. During 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.

Decontamination

Please see Large Laboratory Equipment Decontamination SOP for guidance on how to decontaminate vacuum pumps for repair or disposal.

Waste Management

Standard waste disposal procedures apply of contaminated materials.

First Aid and Emergencies

Spill

Consult the SDS to confirm toxicity information of chemicals spilled. Clean up if able to, then call EH&S for assistance.

Fire

Standard firefighting measures apply.

Personnel Exposure

Standard measures apply.

Laboratory Specific Information

Prior Approval Required

☒ **NO**

☐ **YES (describe):**

Designated Area

- ☐ **Entire Laboratory Area**
- ☒ **Other (describe): Hoods of 1043 and 1050**

Experimental Conditions of Use

Temperature Range: Room Temperature
Pressure Range: varies
Scale Range: <1L

Other Relevant Details:

Standard Operating Procedure

High-Pressure Reaction Vessels

Overview

Failure/explosion of a high-pressure reaction vessel creates a significant and immediate threat from flying debris and reaction constituents. Failure can be caused by a variety of factors including:

- Overloading
- Exceeding temperature/pressure rating
- Reagents incompatible with vessel material

Special Handling and Storage Concerns

Personal Protective Equipment

- Lab Coat, flame resistant if using flammable materials. Also, a chemical resistant apron if using corrosive materials.
- Nitrile or Neoprene Gloves are adequate for possible incidental chemical exposure. Consult a glove chart if extremely toxic or corrosive material is being handled.
- ANSI Z87.1-compliant safety goggles. Goggles and a face shield when performing manipulations while to vessel is at elevated pressure.

Special Storage Requirements

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.

Engineering Controls

Fume Hood: If your protocol does not permit the handling of these materials in a fume hood, EH&S *must* be contacted to assess alternate ventilation options.

Blast Shield: A portable blast shield should be used for small vessels being operated in a fume hood. Custom barricades/shields should be designed for vessels that are not operated inside a fume hood. These barricades/shields should protect in all directions that debris or reaction mixtures could fly in the event of a vessel failure.

Special Handling Considerations

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, understood and consulted regularly.** 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/shield, 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 per the vendor's instructions 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. These include but are not limited to: peroxides, perchlorates, azides, metal acetylides, etc.

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 ^{o}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[1,2] is available for the solvent in use, use this data to calculate to maximum allowable loading using the formula:

Max. Loading Volume = (0.9)(Vessel Volume)/Volume Multiplier at Max. Temp.

Limitations of the Material of Construction

Pressure vessels of identical design but of differing materials of construction will have vastly

[1] **"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.
[2] Parr Instrument Company document No. 230M: **"Safety in the Operation of Laboratory Reactors and Pressure Vessels"**

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.[2]

Decontamination
Consult the SDS to confirm toxicity information of chemicals spilled. Clean up if able to.

Laboratory Specific Information

Waste Management

Standard waste disposal procedures apply. Great care must be taken to ensure that any unreacted material is not released into the laboratory.

First Aid and Emergencies

Spill
Consult the SDS to confirm toxicity information of chemicals spilled. Clean up if able to, then call EH&S for assistance.

Fire
Standard firefighting measures apply.

Personnel Exposure
Standard personnel measures apply.

Prior Approval Required

- ☒ **NO**
- ☐ **YES (describe):**

Designated Area

- ☐ **Entire Laboratory Area**
- ☐ **Other (describe):**

Experimental Conditions of Use

Temperature Range: varies
Pressure Range: varies
Scale Range: <1L

Other Relevant Details:

Standard Operating Procedure

Ethylene Oxide

Overview

Ethylene oxide, or oxirane, is an **extremely flammable** gas at room temperature. Dissolved in water, it remains flammable at a concentration of 4% by volume, making it a serious explosion hazard if poured down the drain.

Ethylene oxide can **self-polymerize violently upon exposure to heat, acid, or base**. Violent reaction can occur with exposure to copper or its alloys, and rust. The heat of burning in a fire may cause the additional hazard of self-polymerization, resulting in explosion.

Ethylene oxide is classified as **Category 1B carcinogen**.

Ethylene oxide is **acutely toxic if inhaled**, causing a variety of symptoms up to and including *headaches, nausea, edema of the lungs, paralysis, convulsions and death*. Its odor threshold is > 200 ppm, while its permissible exposure limit is 1 ppm, therefore the sense of smell does not provide adequate protection against its toxic effects.

Ethylene oxide is **corrosive to tissue**. Symptoms may be delayed. Skin sensitization may also occur. Contact with liquid ethylene oxide can cause severe frostbite.

Special Handling and Storage Concerns

Personal Protective Equipment

- Flame Resistant Lab Coat
- Butyl rubber, Teflon or Silvershield gloves are recommended.
- ANSI Z87.1-compliant safety glasses for very small quantities. Safety goggles/face shield if any splash hazard is present.
- OSHA recommends against contact lens use when working with ethylene oxide.

Special Storage Requirements

Store at 2-8 °C. Incompatible with acids, alkaline salts, copper and rust.

Engineering Controls

All laboratory use must occur inside of a fume hood. This includes the container any plumbing being used to deliver the ethylene oxide into the reaction vessel.

Special Handling Considerations

This material has poor warning properties, as its odor threshold is more than 200 times higher than the permissible exposure limit. Great care must be taken to ensure that there is no leakage of the material into the laboratory.

Explosion-proof equipment and proper grounding and bonding should be used.

Keep away from flame.

Decontamination

Standard decontamination procedures apply. Use great caution in avoiding exposure.

Waste Management

Standard waste disposal procedures apply. Great care must be taken to ensure that any unreacted material is not released into the laboratory.

First Aid and Emergencies

Spill

Treat all spills of benzene as major spills. Do not attempt to clean up the spill yourself. Notify others in the area of the spill, including your supervisor. Evacuate the area and call 911. Remain on-site at a safe distance to provide detailed response to first responders. Report any exposures to EH&S.

Fire

Standard firefighting measures apply.

Personnel Exposure

Skin or eye contact: Remove contaminated attire. Flush affected area with water for 15 minutes. Get medical attention immediately.

Inhalation: Move person to fresh air. Get medical attention immediately.

Ingestion: DO NOT induce vomiting. Rinse mouth with water. Get medical attention immediately.

Laboratory Specific Information

Prior Approval Required

☐ **NO**

☒ **YES (describe):**

Designated Area

☐ **Entire Laboratory Area**

☒ **Other (describe): MRL 1043 (Hood #3)**

Experimental Conditions of Use

Temperature Range: Room Temperature

Pressure Range: varies (Schlenk line)

Scale Range:

Other Relevant Details:

Section II: UC & UCSB policies, procedures and resources

Section III: Appendices: PI responsibilities, Self-Inspection checklist, GHS classification system details, and a list of Particularly Hazardous Substances (PHS)