WORKING WITH ACIDS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

Acids generally used in the lab to prepare buffers and gel staining/destaining solutions. Acids are corrosive substances which cause destruction of living tissue by chemical action at the site of contact and can be solids, liquids, or gases. Corrosive effects can occur not only on the skin and eyes, but also in the respiratory tract and, in the case of ingestion, in the gastrointestinal tract as well.

Mixing various concentrations of aqueous acid solutions - Heat is released when strong acids are mixed with water. If you add water to acid, you form an extremely concentrated solution of acid initially and the solution may boil very violently, splashing concentrated acid. If you add acid to water, the solution that forms is very dilute and the small amount of heat released is not enough to vaporize and spatter it. **Always Add Acid to water, and never the reverse**

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

This applies to all acid solutions. Some examples are:

- Hydrobromic Acid
- Iodic Acid
- Peracetic Acid
- Nitric Acid
- Perchloric Acid
- Hydrochloric Acid
- Hydrofluoric Acid
- Acetic acid
- Benzoic acid
- Chloroacetic Acid
- Formic Acid
- Sulfuric Acid

Most acids are liquids. Acids, especially when in concentrated form, are most likely to cause immediate pain when they come in contact with the body.

Concentrated aqueous solutions of inorganic acids are not in themselves flammable. Combustion can occur when an acid is mixed with other chemicals or with combustible materials. Acids also react with many metals, resulting in the liberation of hydrogen, a highly flammable gas. Some acids are strong oxidizing agents and can react destructively and violently when in contact with other materials. For this reason, it is essential to read warning labels indicating physical hazards.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

a. Eye Protection

At a minimum, chemical splash goggles should be worn. A face shield should be worn when working with larger quantities.

b. Skin and Body Protection

Wear chemical resistant lab coat, long pants, and closed-toe shoes. 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.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

Flame-resistant lab coat will be required, if working with pyrophoric chemicals.

c. Hand Protection

At a minimum, wear a nitrile chemical-resistant glove. Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

4. ENGINEERING/VENTILATION CONTROLS

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Only use if the area is properly equipped with a certified eye wash/safety shower within ten seconds of travel. Inform colleagues that this material will be used and where. Label the work area with a sign saying "Corrosives Use Area."

It is essential that all strong corrosives be stored separately from all chemicals with which they may react. Ensure secondary containment and segregation of incompatible chemicals. Also, follow any substance-specific storage guidance provided in Safety Data Sheet (SDS) documentation.

The corrosive properties of these materials and their ability to produce fires or explosions by combination with combustible materials make the following considerations mandatory in the selection of a storage site:

- A relatively cool, dry environment free from extremes of temperature--humidity should be maintained.

- Acids and bases should be stored in a manner that separates them from other materials and from each other. Each acid or base should be stored in a manner consistent with its properties.
- Stored in material that is acid-resistant; this facilitates flushing and other cleanup procedures in the event of leaks or spills.
- Store on low shelves or in acid/base storage cabinets.
- Segregate oxidizing acids from organic acids, and flammable and combustible liquids.
- Segregate acids from active metals such as sodium, potassium, magnesium, etc.
- Use bottle carriers for transporting materials when possible.
- When mixing acids and water, always add acid to water. NEVER add water to acid!
- Store solutions of inorganic hydroxides in polyethylene containers.
- Store mineral acids together, separate from oxidizing agents and organic materials.
- Store acetic acid and other organic acids with the combustible organic liquids.

Acid Baths:

Acid baths present a serious corrosive hazard and may also present a fire hazard.

1. Preparation, location, use, and disposal all present serious risks and require specific Standard Operating Procedure coverage (PPE, storage, training etc).

2. Emergencies and spills need to be appropriately addressed based on quantities and properties of materials involved.

3. Glassware/labware contaminants must be considered with respect to compatibility with cleaning method.

Wash thoroughly after handling. Do not ingest or inhale nor get in eyes, skin or clothing. Remove contaminated clothing and wash before reuse. Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

- *Small(<500 mL)* – If you have training and do not perceive the risk to be greater than normal laboratory operations, use appropriate personal protective equipment and clean-up materials for chemical spilled. Cover spill with sodium carbonate or bicarbonate (be careful of possible strong reaction). When reaction stops, pickup with damp sponge or paper towels. Place waste in container, label, and arrange for chemical waste pick-up.
- *Large (>500 mL)*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

Chemical Spill on Body or Clothes – Remove clothing and rinse body or affected skin with plenty of water or thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to "Injuries and Medical Treatment" Flipchart posted in the laboratory.

7. DECONTAMINATION

Wear proper PPE, decontaminate equipment and bench tops using sodium bicarbonate and water. Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.

- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with Acid Solutions must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

Work should be completed in a laboratory fume hood designated for Acid Solutions.

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

12. DETAILED PROTOCOL

- ✓ Never handle concentrated or diluted acids without required PPE.
- ✓ Work with diluted acids only in designated area (chemical fume hood)
- ✓ Dilute concentrated acid acids to working solution.
- ✓ Always pour acid into water. "Water first, acid second"
- ✓ Do not pour water into concentrated acids, as this may cause a violent exothermic reaction resulting in spills and serious injuries.
- ✓ Do not mix acids.
- ✓ Do not mix concentrated acids with concentrated bases.

1.) Prepare 1M HCl stock solution

- Move equipment under hood
- Wear required PPE.
- Have a 36.5% HCl solution (purchased from company).
- Add 90 mL H_2O in beaker.
- Fill 10 mL of the HCl solution in beaker.
- Add acid to water, mix using magnetic stirrer.
- Transfer solution to storage.

2.) PH adjustment

- Under hood, remove aliquots of NaOH from stock solution.

- Dropwise add stock solution to buffer until desired pH has been reached.
- Avoid breathing in fumes. For adjustment of pH of large volumes, perform pH adjustment under fume hood.

All lab workers who will be using Acid Solutions must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of Acid Solutions and understand the hazards.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) employ < 100 mL of Acid Solutions in any given reaction (larger quantities REQUIRE the approval of PI or designee), and
5) discuss ALL issues or concerns regarding Acid Solutions with the PI prior to its use.

If there is an unusual or unexpected occurrence when using Acid Solutions, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Acid Solutions. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name

Signature

Approval Date: 02/01/2013

ACUTELY TOXIC CHEMICALS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

There is a broad spectrum of toxic materials. Increased recognition of the hazards associated with the transportation, operation, and storage of these materials is essential.

2. CLASS OF HAZARDOUS CHEMICAL(S)

An acutely toxic material is considered a chemical falling within any of the following categories:

- A chemical with a median lethal dose (LD50) of 50 mg or less per Kg of body weight when administered orally to albino rats weighing between 200 and 300 gm each.
- A chemical with a median lethal dose (LD50) of 200 mg or less per Kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 Kg each.
- A chemical that has a median lethal concentration (LC50) in air of 5000 ppm by volume or less of gas or vapor, or 50 mg per liter or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 gm each.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, the following PPE must be worn at all times:

a. Eye Protection

ANSI compliant safety glasses with side shields should be worn. Chemical splash goggles should be worn when working with larger quantities. If chemical has a skin hazard or is a caustic liquid, a face shield should be worn when splashing onto the face is a possibility.

b. Skin and Body Protection

Wear chemical resistant lab coat, long pants, and closed-toe shoes. 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.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

Flame-resistant lab coat will be required, if working with pyrophoric chemicals.

c. Hand Protection

At a minimum, wear a nitrile chemical-resistant glove. Never re-use disposable gloves, such as nitrile. If there is a risk of explosion, Kevlar gloves must be worn.

Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

4. ENGINEERING/VENTILATION CONTROLS

- All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.
- Use containment devices (such as lab fume hoods or glove boxes) when: (i) volatilizing these substances, (ii) manipulating substances that may generate aerosols, and (iii) performing laboratory procedures that may result in uncontrolled release of the substance.
- Use high efficiency particulate air (HEPA) filters, carbon filters, or scrubber systems with containment devices to protect effluent and vacuum lines, pumps, and the environment whenever feasible.
- Use ventilated containment to weigh out solid chemicals. Alternatively, the tare method can be used to prevent inhalation of the chemical. While working in a laboratory hood, the chemical is added to a pre-weighed container. The container is then sealed and can be re-weighed outside of the hood. If chemical needs to be added or removed, this manipulation is carried out in the hood. In this manner, all open chemical handling is conducted in the laboratory hood.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Wash thoroughly after handling. Do not ingest or inhale nor get in eyes, skin or clothing. Remove contaminated clothing and wash before reuse.

Store in a tightly closed, labeled container and in a cool, dry well-ventilated area. Segregate from incompatible materials. Secondary containers must be labeled clearly.

Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

- *Small* – If you have training, use appropriate personal protective equipment and clean-up materials for chemical spilled. Double bag spill waste in clear plastic bags, label, and arrange for chemical waste pick-up.
- *Large*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

Chemical Spill on Body or Clothes – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to “Injuries and Medical Treatment” Flipchart posted in the laboratory.

7. DECONTAMINATION

Wear proper PPE. Decontamination procedures vary depending on the material being handled. The toxicity of some materials can be neutralized with other reagents. All surfaces should be wiped with the appropriate cleaning agent following dispensing or handling. Dispose of all used contaminated disposables and waste as hazardous waste following the Waste Disposal Section.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Label all waste with the chemical contents and the appropriate hazard warning.
- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with Acutely Toxic Materials must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

A designated area shall be established where limited access, special procedures, knowledge, and work skills are required. A designated area can be the entire laboratory, a specific laboratory workbench, or a laboratory hood. Designated areas must be clearly marked with signs that identify the chemical hazard and include an appropriate warning; for example: WARNING! HIGHLY ACUTELY TOXIC MATERIAL WORK AREA!

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

12. DETAILED PROTOCOL

All lab workers who will be using Acutely Toxic Chemicals must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of Acutely Toxic Chemicals and understand the hazards.

Lab workers using Acutely Toxic Chemicals must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedent for reaction conditions that have reasonable similarities to new chemistry that is planned with Acutely Toxic Chemicals described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone (if you are alone in the laboratory, leave);
2) be cognizant of all of the SDS and safety information presented in this document;
3) find/follow a literature experimental procedure describing the use of this reagent covered by this SOP in a related chemical transformation. If a pertinent literature protocol cannot be found, the researcher MUST discuss the planned experiment with the PI (or designee) prior to using this reagent;
4) not deviate from the literature experimental protocol mentioned in (3) in either temperature or pressure without PRIOR APPROVAL from the PI (or designee);
5) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
6) employ < 10 mL of this Acutely Toxic Chemicals in any given reaction (larger quantities REQUIRE the approval of PI or designee), and
7) discuss ALL issues or concerns regarding this Acutely Toxic Chemicals with the PI prior to its use.

If there is an unusual or unexpected occurrence when using Acutely Toxic Chemicals, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Acutely Toxic Chemicals. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in

temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name

Signature

Approval Date: 02/01/2013

ACUTELY TOXIC GASES
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

There is a broad spectrum of toxic compressed gases. Increased recognition of the hazards associated with the transportation, operation, and storage of these gases is essential.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

Toxic gases are gases that may cause significant acute health effects at low concentrations. Health effects may include severe skin or eye irritation, pulmonary edema, neurotoxicity, or other potentially fatal conditions. The criteria used to establish the list are: (1) A National Fire Protection Association (NFPA) health rating of 3 or 4; (2) An NFPA health rating of 2 with poor physiological warning properties; (3) Pyrophoric (self-igniting) characteristics; or (4) Extremely low occupational exposure limits in the absence of an NFPA health rating.

Some Common Acutely Toxic Gases:

- Anhydrous ammonia
- Arsine
- Carbon Monoxide
- Chlorine
- Dichlorosilane
- Fluorine
- Hydrogen chloride
- Hydrogen sulfide
- Nitric Oxide
- Phosgene
- Phosphine
- Vinyl chloride

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

a. Eye Protection

ANSI compliant safety glasses with side shields should be worn. Chemical splash goggles should be worn when working with larger quantities. If chemical has a skin hazard or is a caustic liquid, a face shield should be worn when splashing onto the face is a possibility.

b. Skin and Body Protection

Wear chemical resistant lab coat, long pants, and closed-toe shoes. 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.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

Flame-resistant lab coat will be required, if working with pyrophoric chemicals.

c. Hand Protection

At a minimum, wear a chemical-resistant glove. Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

4. ENGINEERING/VENTILATION CONTROLS

A ventilation monitor is required on each lab hood or gas cabinet in which toxic gases are used and stored. Acceptable monitors include audible and visual alarms, magnehelic gauge, inclined manometer, or other devices which indicate that the enclosure is actively ventilated. Manometers and gauges should be clearly marked to indicate safe pressure limits.

Electronic toxic gas monitors with alarms should be installed and continuously operated wherever a toxic gas is used which has a high concentration, large quantity, and/or poor physiological warning properties (odor or irritation). The requirement for a monitoring system will be decided on a case-by-case basis and will be required more commonly for continuous operations and long term research situations. A toxic gas has poor warning properties when such properties are only noticeable at or above harmful concentrations (e.g., the PEL). Some toxic gases have poor warning properties. Gas monitoring equipment must be able to detect concentrations at or below the PEL.

Toxic gas monitors and alarms should be connected to an emergency power source. In the event of a power failure, the detection system should continue to operate without interruption, or gas systems should automatically shut down at the source. Power connections, control switches, and adjustments that affect the detection system operation should be protected from direct access by locks on the enclosures.

All gas monitoring systems should have:

- Audible and visible alarms in the following locations: gas supply location, gas use or operator room, and outside the gas use room (e.g., corridor).
- An alarm status and gas concentration readout panel located outside the gas use room.
- Local audible and visual alarms specific and distinct from fire alarm bells and signs to indicate the alarm's meaning and required personnel action.
- The toxic gas alarm level setpoint set at the PEL or Threshold Limit Value.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

All transport of toxic gases between on-campus locations must be conducted as follows:

- Gas cylinders must be secured to the transport vehicle (cart, motor vehicle, hand truck, etc.).
- Cylinders must be continuously attended during transport.
- Cylinders must be clearly labeled with content and hazard information.
- Cylinder caps must be in place.

These requirements apply to all listed toxic gas containers, including empty and partially full cylinders.

Upon receipt of toxic gases, cylinders shall be temporarily stored in a well-ventilated area that is attended or locked at all times. All cylinders shall be immediately leak tested with a leak indicating solution and must be clearly labeled with content and hazard information. Temporary storage locations shall have appropriate signage in place. Cylinders must be seismically secured at all locations with chains at two contact points on the cylinder body, using unistruts or an equivalent. Seismic securing should prevent cylinders from rolling, shifting, or falling.

Laboratory storage of all toxic gas cylinders shall be in a mechanically ventilated, lockable area. Examples of mechanical ventilation include vented gas cabinets and fume hoods. Rooms containing toxic gases shall be locked when not occupied by authorized persons. All cylinders and gas cabinets must be clearly labeled with content and hazard information. Cylinders shall be seismically secured at all locations with chains (2 contact points), using unistruts or an equivalent for cylinders larger than lecture bottles. Lecture bottles must be secured to a stable surface. Outdoor storage is only allowed on a short term basis in a secure area at least 75 feet from an exterior door, window, or air intake location.

All regulators, valves, and lines must be chemically compatible with the gases being used. Compatibility can be determined by contacting the gas vendor or by calling EH&S. Regulator/line systems must be leak tested immediately after assembly and before each use. Regulators shall be compatible with the size and type of gas cylinder being used, and rated for full cylinder pressure.

All toxic gas cylinders and reaction vessels/chambers shall be kept in ventilated enclosures during use and storage. Air-flow velocities at all openings in the vented enclosures must be 0.5 m/s (100 fpm) or greater while in the open position. Where regular access is needed, small access doors must be used to minimize exhaust flow reduction.

All lines or ducts carrying purged or exhausted emissions of toxic gases must be connected to a mechanical exhaust system that discharges to a safe location (i.e.,

presents no potential for re-entrainment into any building supply air intake or occupied area). Exhaust duct walls shall be chemically resistant to degradation by the toxic gas in use.

Significant emissions of corrosive or toxic gases require an emission control device (e.g., scrubber, flare device, adsorbent) before the purged gas can be vented into the exhaust duct system. Significant emissions are defined as duct concentrations that result in duct corrosion or acute health risk to persons exposed near exhaust fan stacks as determined by release modeling. When toxic gases are emitted from exhaust systems at concentrations which could pose health risks to rooftop workers, locked gates, doors, or other means shall be used to prevent worker access to stack discharge areas. Warning signs must be conspicuously placed.

STORAGE:

It is essential that all acutely toxic gases be stored separately from all chemicals with which they may react. Ensure segregation of incompatible chemicals per guidance within the UCR Chemical Hygiene Plan. Also, follow any substance-specific storage guidance provided in Safety Data Sheet (SDS) documentation.

6. SPILL AND INCIDENT PROCEDURES

Emergency procedure for leaking gas cylinders - http://www.airproducts.com/~/media/Files/PDF/company/safetygram-11.pdf

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to “Injuries and Medical Treatment” Flipchart posted in the laboratory.

7. WASTE DISPOSAL

All empty toxic gas cylinders shall be labeled as empty. Depleted toxic gas cylinders should be returnable to the vendor according to their guidelines. The purchase of any gases that will not be completely used in the course of research must be approved by the vendor for return, or by EH&S for disposal as hazardous waste. Disposal of toxic gas cylinders by EH&S, even when empty, may entail extraordinary costs. Therefore, toxic gases should be purchased only from vendors who will accept returns.

All other hazardous waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

8. PRIOR APPROVAL/REVIEW REQUIRED

All work with Acutely Toxic Gases must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

9. DESIGNATED AREA

A designated area shall be established where limited access, special procedures, knowledge, and work skills are required. A designated area can be the entire laboratory, a specific laboratory workbench, or a laboratory hood. Designated areas must be clearly marked with signs that identify the chemical hazard and include an appropriate warning; for example: WARNING! ACUTELY TOXIC GAS WORK AREA!

10. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

11. DETAILED PROTOCOL

All lab workers who will be using Acutely Toxic Gases must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of Acutely Toxic Gases and understand the hazards.

Lab workers using Acutely Toxic Gases must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly

hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedent for reaction conditions that have reasonable similarities to new chemistry that is planned with Acutely Toxic Gases described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) use Acutely Toxic Gases under < 1 bar in any given reaction (larger quantities REQUIRE the approval of PI or designee), and
5) discuss ALL issues or concerns regarding this Acutely Toxic Gases with the PI prior to its use.

Replace empty gas cylinder

1) In case of carbon monoxide, ensure carbon monoxide detector is on
2) Borrow a proper dolly from department stockroom.
3) Close the main cylinder valve.
4) Slowly release pressure from regulator into hood to vent.
5) Close the regulator valves.
6) Disconnect the regulator from an empty cylinder.
7) Screw cylinder cap.
8) Deliver the empty cylinder to the stockroom or store temporally in one of hall cabinets.
9) Bring a new gas cylinder to the rack.
10) Safely secure the cylinder using chain clamp.
11) Unscrew cylinder cap.
12) Ensure the main valve is closed.
13) Unscrew the main valve cap.
14) Connect the regulator to the cylinder.
15) Fully open the regulator valves.

16) Get vacuum in the gas manifold and the regulator.
17) Closed the diaphragm valve.
18) Quickly open and close the main cylinder valve to see if the diaphragm valve is working well.
19) If the good sealing is obtained, go ahead. Otherwise, pump the gas in the line and replace the regulator.
20) Set a delivery pressure as needed.
21) Carefully release pressure from regulator.
22) Fully open the main cylinder valve if needed.

If there is an unusual or unexpected occurrence when using Acutely Toxic Gases, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Acutely Toxic Gases. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name


Signature

Approval Date: 02/01/2013

BASES
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

Bases are generally used in the laboratory to prepare buffers (adjust pH).

Corrosive substances cause destruction of living tissue by chemical action at the site of contact and can be solids, liquids, or gases. Corrosive effects can occur not only on the skin and eyes, but also in the respiratory tract and, in the case of ingestion, in the gastrointestinal tract as well. Corrosive liquids are especially dangerous because their effect on tissue generally takes place very rapidly. A number of solid chemicals have corrosive effects on living tissue. An example of common corrosive solid is sodium hydroxide. Dust from corrosive solids can be inhaled and cause serious damage to the respiratory tract.

Strong bases, such as the metal hydroxides and ammonia, make up a class of corrosive chemicals. Strong dehydrating agents, such as phosphorus pentoxide and calcium oxide, have a powerful affinity for water and can cause serious burns upon contact with the skin. Finally, strong oxidizing agents, such as concentrated solutions of hydrogen peroxide, can also have serious corrosive effects and should never come into contact with the skin or eyes.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

This SOP addresses the class of hazardous chemicals known as bases. Several examples include:

- Ammonium hydroxide
- Barium hydroxide
- Calcium hydroxide
- Potassium hydroxide
- Sodium hydroxide
- Lithium hydroxide
- Biocarbonates – Salts of potassium bicarbonate, etc.
- Carbonates

Solid bases, when dissolved in water, can cause serious damage to eyes and skin by their corrosive action. Fine dust from almost any solid base can cause severe damage to the eyes, upper respiratory tract, and lungs. Fine dust can also cause skin irritation, particularly to persons who have become wet or perspire freely.

All of these materials are corrosive and will destroy body tissue. The seriousness of the injury depends on such factors as the type and concentration of the chemical, the body parts contacted, and the speed used in applying emergency measures.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

a. Eye Protection

ANSI compliant safety glasses with side shields should be worn. Chemical splash goggles should be worn when working with larger quantities. A face shield should be worn when splashing onto the face is a possibility.

b. Skin and Body Protection

Wear chemical resistant lab coat, long pants, and closed-toe shoes. 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.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

c. Hand Protection

At a minimum, wear a chemical-resistant glove (e.g. nitrile rubber). Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

4. ENGINEERING/VENTILATION CONTROLS

All concentrated bases should be transferred and dispensed in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Only use if the area is properly equipped with a certified eye wash/safety shower within ten seconds of travel. Inform colleagues that this material will be used and where. Label the work area with a sign saying "Corrosives Use Area."

Store in a tightly closed, labeled container and in a cool, dry well-ventilated area. Ensure secondary containment and segregate from incompatible materials. Secondary containers must be labeled clearly. Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

The corrosive properties of these materials and their ability to produce fires or explosions by combination with combustible materials make the following considerations mandatory in the selection of a storage site:

- ✓ A relatively cool, dry environment free from extremes of temperature--humidity should be maintained.
- ✓ Acids and bases should be stored in a manner that separates them from other materials and from each other. Each acid or base should be stored in a manner consistent with its properties.
- ✓ Stored in material that is acid-resistant; this facilitates flushing and other cleanup procedures in the event of leaks or spills.
- ✓ Store on low shelves or in acid/base storage cabinets.
- ✓ Use bottle carriers for transporting materials when possible.
- ✓ Store solutions of inorganic hydroxides in polyethylene containers.

Acid/Base Baths:

Acid and/or base baths present a serious corrosive hazard and may also present a fire hazard.

1. Preparation, location, use, and disposal all present serious risks and require specific Standard Operating Procedure coverage (PPE, storage, training etc).

2. Emergencies and spills need to be appropriately addressed based on quantities and properties of materials involved.

3. Glassware/labware contaminants must be considered with respect to compatibility with cleaning method.

Wash thoroughly after handling. Do not ingest or inhale nor get in eyes, skin or clothing. Remove contaminated clothing and wash before reuse.

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

- *Small* – If you have training, use appropriate personal protective equipment and clean-up materials for chemical spilled. Double bag spill waste in clear plastic bags, label, and arrange for chemical waste pick-up.

- *Large*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

Chemical Spill on Body or Clothes – Remove clothing and rinse body or affected skin with plenty of water or thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to "Injuries and Medical Treatment" Flipchart posted in the laboratory.

7. DECONTAMINATION

Wear proper PPE. Collect any crystals with brush – avoid creating dust. Decontaminate equipment and bench tops. Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with Bases must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

Work should be completed in a laboratory fume hood designated for Bases.

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

12. DETAILED PROTOCOL

Absorbent bench paper should be used with handling bases. Bench paper should be disposed upon contamination from spilling or after usage.

Handling Bases

- ✓ Wear appropriate PPE.
- ✓ Change gloves after handling.
- ✓ Waste container should be properly labeled and stored in chemical fume hood until disposal.
- ✓ Work in a chemical fume hood for high concentrated base solutions (>0.5 M)
- ✓ All general safe work practices should be followed when working with bases (i.e. no eating, drinking, chewing gum, etc).

All lab workers who will be using Bases must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of Bases and understand the hazards.

Lab workers using Bases must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) employ < 100 mL of 1 N Bases in any given reaction (larger quantities REQUIRE the approval of PI or designee), and
5) discuss ALL issues or concerns regarding this Bases with the PI prior to its use.

If there is an unusual or unexpected occurrence when using Bases, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Bases. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name


Signature

Approval Date: 02/01/2013

FLAMMABLE LIQUIDS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

The **flashpoint** of a flammable liquid is the lowest temperature at which it can form an ignitable mixture with air and produce a flame when a source of ignition is present.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

Flammable liquids are chemicals that have a flash point below 100º F (38.7º C) and a vapor pressure that does not exceed 40 psig at 100º F.

Flammable liquids are commonly divided into three classes

Class	Flash Point	Boiling Point	Example
IA	Below 73°F	Below 100 °F	Ethyl Ether
IB	Below 73 °F	At or above 100 °F	Acetone, Benzene, Toluene
IC	At or above 73°F and below 100°F		Methanol, Isopropanol, Xylene

Combustible liquids are divided into three classes

Class	Flash Point	Example
II	100-139 °F	Acetic acid, cyclohexane, and mineral spirits
IIIA	140-199 °F	Cyclohexanol, formic acid and nitrobenzene
IIIB	200 °F or above	Formalin and vegetable oil

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

a. Eye Protection

ANSI compliant safety glasses with side shields should be worn. Chemical splash goggles should be worn when working with larger quantities. If chemical has a skin hazard or is a caustic liquid, a face shield should be worn when splashing onto the face is a possibility.

b. Skin and Body Protection

Wear flame-resistant lab coat, long pants, and closed-toe shoes. 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.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

c. Hand Protection

At a minimum, wear a nitrile chemical-resistant glove. Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

4. ENGINEERING/VENTILATION CONTROLS

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

- Safety Shielding: Shielding is required any time there is a risk of explosion, splash hazard or a highly exothermic reaction. All manipulations of flammable liquids 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.
- Special Ventilation: Manipulation of flammable liquids outside of a fume hood may require special ventilation controls in order to minimize exposure to the material. Fume hoods provide the best protection against exposure to flammable liquids in the laboratory and are the preferred ventilation control device. Always attempt to handle quantities of flammable liquids greater than 500 mL in a fume hood. If your research does not permit the handing of large quantities of flammable liquids in your fume hood, contact the EHS to review the adequacy of all special ventilation.
- Vacuum Protection: Evacuated glassware can implode and eject flying glass, and chemicals. Vacuum work involving flammable liquids must be conducted in a fume hood, glove box or isolated in an acceptable manner. Mechanical vacuum pumps must be protected using cold traps and, where appropriate, filtered to prevent

particulate release. The exhaust for the pumps must be vented into an exhaust hood. Vacuum pumps should be rated for use with flammable liquids.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Use in an area that is properly equipped with a certified eye wash/safety shower and is available within ten seconds of travel.

Wash thoroughly after handling. Do not ingest or inhale nor get in eyes, skin or clothing. Remove contaminated clothing and wash before reuse.

Store in a tightly closed, labeled container and in a cool, dry well-ventilated area. Segregate from incompatible materials. Secondary containers must be labeled clearly. Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

- **Flammable Liquid Storage Cabinets**

  - ✓ One or more Flammable Liquid Storage Cabinets (FLSC) are required for laboratories which store, use or handle more than 5 gallons of flammable or combustible liquids.
  - ✓ Containers one gallon and larger of flammable liquids must be stored in a flammable-liquids storage cabinet.
  - ✓ The storage of flammable and combustible liquids in a laboratory, shop, or building area must be kept to the minimum needed for research and/or operations. FLSC are not intended for the storage of highly toxic materials, acids, bases, compressed gases or pyrophoric chemicals.
  - ✓ In most university laboratories flammable liquids storage is provided under the chemical fume hood. These cabinets are clearly marked “Flammable Storage”. Flammable liquids storage cabinets are constructed to limit the internal temperature when exposed to fire. When additional storage is needed, NFPA 30-4.3.3 approved flammable liquids storage cabinet (FLSC) may be purchased. All containers of flammable liquids must be stored in a FLSC when not in use. The following requirements apply:

    <u>General Requirements</u>

    - Cabinets shall be no larger than 45 gallon capacity
    - Cabinets should be located near fume hood alcoves
    - Cabinets shall be marked “Flammable-Keep Fire Away”
    - Cabinets should be kept in good condition. Doors that do not close and latch must be repaired or the cabinet must be replaced.

- ✓ Flammable liquids storage cabinets are equipped with a grounding system that can be connected to a building ground. If you are pouring from a container in the storage cabinet and if the container being poured into is conductive then a bonding strap must be attached between them as explained in PROCEDURES TO AVOID STATIC ELECTRICITY.

- **Transferring/Dispensing**

STATIC ELECTRICITY HAZARDS IN THE LABORATORY

The flow of flammable and combustible liquids can cause the buildup of static electricity. When enough of a charge is built up a spark can result and potentially cause a fire or explosion. The likelihood of this happening is dependent upon how well the liquid conducts electricity, the flash point and the capacity to generate static electricity.

Static electricity can be generated when liquid is transferred from one metal container to another. Liquids have the ability to generate static electricity when they move in contact with other materials during pouring, pumping or agitating. The build up of this static electricity can cause a spark to form where the solvent exits the container. This could result in a fire or explosion.

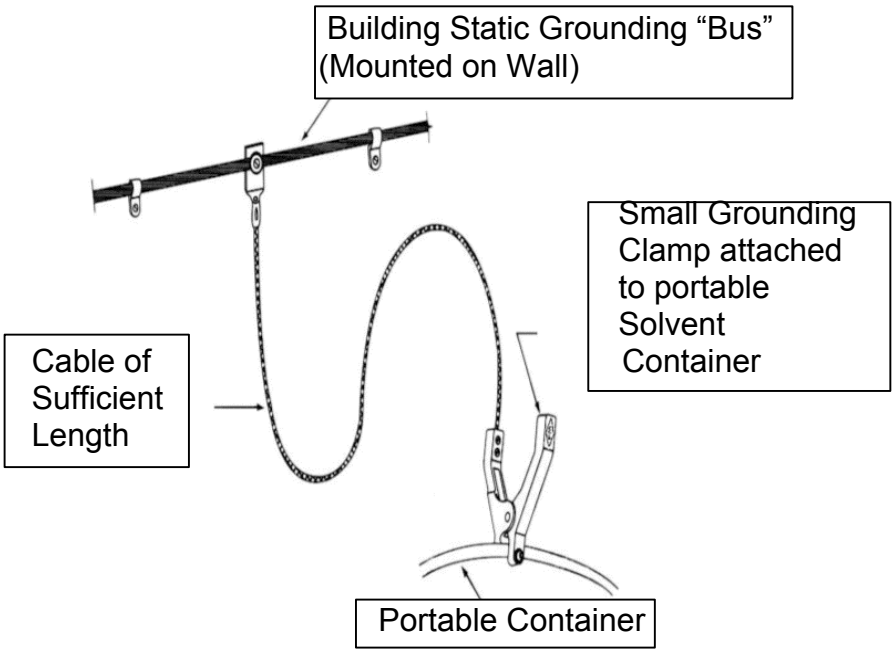
PROCEDURES TO AVOID STATIC ELECTRICITY

To avoid the buildup of static electricity that may cause a spark, it is important to bond and ground metal or special conductive plastic containers. **Bonding** eliminates the electrical potential between two containers therefore eliminating the likelihood of sparks. A bonding wire is connected to two conductive objects as seen in the drums pictured below.

Bonding wires between drums

Grounding eliminates the difference in static potential charge between the conductive object and ground. Grounding is accomplished by connecting the conductive object directly to the earth, usually using cold water copper pipes, building steel or grounding bus/bar.

Bonding and grounding require good electrical connections. Remove any dirt, paint or rust ensuring **metal to metal** contact.



Bonding and Grounding wires come in a variety of styles and lengths. They can be purchased through Fisher Scientific:, Justrite Manufacturing: and through Lab Safety Supply:

Hand Clamp

'C' Clamp and Alligator Clip

Static hazards may also exist in non-metallic plastic or glass containers that cannot be grounded. Static may be generated by the free fall and turbulence of the liquid being poured. To minimize this hazard, pour as slowly as possible and use a grounded nozzle extension that allows filling the container from the bottom.

DISPENSING FLAMMABLE LIQUIDS FROM 5 GALLON PAILS

Manual dispensing pumps for 5-gallon pails/cans are available. These pumps are specifically designed to dispense liquids into small laboratory-size bottles without spilling. If you are pouring into a conductive container, a bonding wire should be attached from the 5-gallon pail to the container being filled. The 5-gallon pail should be grounded.

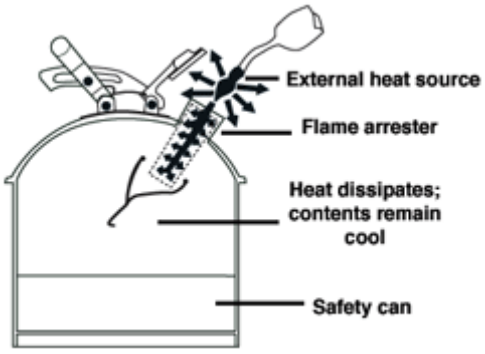
The dispenser shown in the picture below can be purchased through Fisher Scientific. The metal strap in the picture hooks over the bottom of the pail and secures the dispenser while pumping.

Two adapters are provided with the dispensing pump from Fisher (grey and black). Use the appropriate adapter to achieve the correct seal with the solvent container you have.

Some solvent containers have a grey fitting at the opening, and others have the black one.

DISPENSING FLAMMABLES FROM SAFETY CANS

Safety cans have self-closing air tight lids and a flame arrester that protects the contents from an external ignition source. Bonding and grounding is still required on safety cans since static electricity generation is possible. The nozzle provides a bonding path to a receiving metallic vessel.



If either of the containers are non-metallic (conductive) it is still important to follow the limited velocity and grounded nozzle extension information given previously.

Safety can with extended nozzle

Safety cans do not offer protection from heat when exposed to fire and should be stored in a flammable liquids storage cabinet when not in use.

- **Labeling**
  - ✓ All flammable liquids must be clearly labeled with the correct chemical name.
  - ✓ Handwritten labels are acceptable; chemical formulas and structural formulas are not acceptable.

- ✓ The label on any containers of flammable liquids should say "Flammable" and include any other hazard information, such as "Corrosive" or "Toxic", as applicable.

- **Heating/Open flame**
  - ✓ Do not store flammable liquids in chemical fume hoods or allow containers of flammable liquids in proximity to heating mantles, hot plates, or torches.
  - ✓ With the exception of vacuum drying ovens, laboratory ovens rarely have any means of preventing the discharge of material volatilized within them. Thus it should be assumed that these substances will escape into the laboratory atmosphere, but may also be present in sufficient concentration to form explosive mixtures within the oven itself. Venting the oven to an exhausted system will reduce this hazard.
  - ✓ Drying ovens should not be used to dry glassware that has been rinsed with organic solvents until the majority of the solvent has had the opportunity to drain or evaporate at room temperature.
  - ✓ Do not use mercury thermometers to monitor oven temperatures. Accidental breakage of the thermometer will cause a serious hazard since uncontained mercury will volatilize very rapidly.

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

- *Small* – If you have training, use appropriate personal protective equipment and clean-up materials for chemical spilled. Double bag spill waste in clear plastic bags, label, and arrange for chemical waste pick-up.
- *Large*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

Chemical Spill on Body or Clothes – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye

open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to "Injuries and Medical Treatment" Flipchart posted in the laboratory.

7. DECONTAMINATION

Wear proper PPE, decontaminate equipment and bench tops using soap and water. Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with Flammable Liquids must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

Work should be completed in a laboratory fume hood designated for Flammable Liquids.

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

12. DETAILED PROTOCOL

All lab workers who will be using Flammable Liquids must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of Flammable Liquids and understand the hazards.

Lab workers using Flammable Liquids must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedent for reaction conditions that have reasonable similarities to new chemistry that is planned with Flammable Liquids described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) employ < 100 mL of this Flammable Liquids in any given reaction (larger quantities REQUIRE the approval of PI or designee), and
5) discuss ALL issues or concerns regarding this Flammable Liquids with the PI prior to its use.

If there is an unusual or unexpected occurrence when using Flammable Liquids, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Flammable Liquids. Unusual or unexpected

occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name

Signature

Approval Date: 02/01/2013

UC RIVERSIDE UNIVERSITY OF CALIFORNIA

PEROXIDE FORMING CHEMICALS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

Organic peroxides are among the most hazardous substances handled in the chemical laboratory. They are generally low-power explosives that are sensitive to shock, sparks, or other accidental ignition. They are far more shock-sensitive than most primary explosives such as TNT.

Organic peroxides are organic compounds containing the peroxide functional group (ROOR'). These materials are sensitive to oxygen, heat, friction, impact, light, and strong oxidizing and reducing agents.

Peroxide formation may occur when certain chemicals (see section 2) are stored for prolonged periods, concentrated through distillation, evaporation or air exposure, and also as a result of polymerization.

Peroxide forming chemicals are compounds that undergo auto-oxidation to form organic hydroperoxides and/or peroxides when exposed to the oxygen in air. Especially dangerous are ether bottles that have evaporated to dryness. A peroxide present as a contaminant in a reagent or solvent can be very hazardous and can change the course of a planned reaction. Autoxidation of organic materials (solvents and other liquids are most frequently of primary concern) proceeds by a free-radical chain mechanism. For the substrate R—H, the chain is initiated by ultraviolet light.

The unusual stability problems of this class of compounds make them a serious fire and explosion hazard that requires careful management.

2. HAZARDOUS CHEMICALS/CLASS OF HAZARDOUS CHEMICALS

The following are some organic class of compounds prone to forming peroxides:

- Aldehydes
- Ethers, especially cyclic ethers and those containing primary and secondary alkyl groups (never distill an ether before it has been shown to be free of peroxide)
- Compounds containing benzylic hydrogen
- Compounds containing allylic hydrogens (C=C-H), including most alkenes; vinyl and vinylidene compounds
- Compounds containing a tertiary C-H group (e.g., decalin and 2,5-dimethyl hexane)

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, the following PPE must be worn at all times:

1. Eye Protection

    a. Safety glasses with side shields or splash goggles that meet the ANSI Z.87.1 1989 standard. When there is the potential for splashes, goggles must be worn.

    b. Face shields must only be used over either safety spectacles or goggles (for face protection).

2. Skin Protection

    a. Lab coat. For hazardous chemicals that are toxic by skin contact/absorption, additional protective clothing (i.e., oversleeves) is appropriate where chemical contact w/ body/ skin is foreseeable.

        i. Fully extend sleeves to the wrists.

        ii. Buttoned at all times.

        iii. If significant risk of fire exists, a fire-resistant lab coat with a higher flammability resistance rating should be worn.

    b. Rubber aprons when large quantities are handled.

    c. Non-synthetic clothing should be worn.

    d. Gloves.

        i. When handling hazardous chemicals or contacting potentially contaminated surfaces, protective gloves are to be worn.

        ii. Wear gloves to prevent skin exposure. In a glove box, use the glove box gloves and sleeves. If this chemical is handled in a closed system in a certified fume hood, use appropriate chemical resistant gloves.

    NOTE: Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the specific peroxide former.

    Refer to glove selection chart from the links below:

    http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or

    http://www.allsafetyproducts.biz/page/74172 or

    http://www.showabestglove.com/site/default.aspx or

    http://www.mapaglove.com/

        iii. Never re-use disposable gloves, such as nitrile.

iv. If there is a risk of explosion, Kevlar gloves must be worn.

e. Close-toed, closed-heel shoes.

f. Covered legs.

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

3. Hygiene Measures

Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

4. ENGINEERING/VENTILATION CONTROLS

1. Must follow the UCR EH&S Compressed Gas Fast Facts (http://ehs.ucr.edu/resources/compressedgas.pdf) if the peroxide forming chemical is a compressed gas.
2. Use at least one of the following engineering controls:
   a. Fume hood: Work inside a certified chemical fume hood at all times.
   b. Glove box: When inert or dry atmospheres are required.
   c. Portable explosion shield: May also be required to control the risk of explosion.
   d. Gas cabinet: If the material is classified as a compressed gas.
3. Use bonding and grounding equipment to minimizing the likelihood of an ignition from static electricity during the transfer of all Class I flammable liquids.
4. Know where your safety equipment is located (i.e., fire extinguisher, eye wash/safety shower, and first aid kit).
5. Have the appropriate fire extinguisher available.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

1. Never work alone. At least one other person must be present in the same laboratory when any work involving peroxide forming chemicals is carried out.
2. Eliminate or substitute a less hazardous material when possible.
3. Design your experiment to use the least amount of material possible to achieve the desired result.
4. Verify your experimental set-up and procedure prior to use.
5. Ensure all equipment is appropriate for the task.
6. Establish a designated area:
   1. Clear the area of unrelated and possibly incompatible hazards.
   2. Keep container sizes and quantities in the work area as small as possible.
   3. Transport material in secondary containers and only in small quantities.
7. Only use if the area is properly equipped with a certified eye wash/safety shower reachable within ten seconds.

8. Avoid inadvertent incompatibles:
   a. Heat sources, open flames and oxidizers
   b. Consult with the campus Chemical Hygiene Officer if work involves large quantities.

Diethyl ether must be used in a fume hood. THF-containing mobile phase must be prepared in the fume hood but may be used outside of the fume hood on the HPLC equipment so long as the mobile phase supply container is covered. Refrigeration of diethyl either is not recommended. Reduced temperature can impede the peroxide-scavenging ability of added preservatives and actually increase peroxide formation.

STORAGE:

1. Purchase and use the minimum amount of material necessary to perform your research.
2. Label peroxide forming materials clearly and promptly upon receipt or synthesis.
3. Store all peroxide forming materials inside of a flammable cabinet or high hazard room (H room).
4. Review your inventory frequently to prevent peroxide forming chemicals from becoming unsafe.
5. Test materials for peroxide formation according to guidance set forth in the peroxide forming materials information.
6. Do not handle old or expired peroxide forming materials that are discovered. Inform your Principal Investigator immediately and dispose of the item as a hazardous waste.
7. Ether solvents: Ether solvents stored in solvent drying cartridge manifolds can be excluded since these are kept air-free under a positive pressure of inert gas. The dangers associated with ether solvents depend on and can be exacerbated by these factors:
   a. Exposure to air (oxygen)
   b. Exposure to light
   c. Temperature
   d. Friction
   e. Shock
   f. Concentration
   g. Chemical structure
   h. Distillation that removes stabilizers
   i. Slow evaporation of volatile ethers over time
   j. Impurities

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Spills should be immediately and thoroughly cleaned up. Proceed only if you will not injure yourself or others and it is not an emergency and not likely to become an

emergency. Work areas should be marked with an indicator that peroxide forming chemicals are in use or exposed. Keep a chemical spill kit easily accessible. In the case of strong corrosives, consider the likelihood of fire. If you are unsure about how to clean up a spill, contact EH&S for help.

For larger spills, evacuate the lab, close the door and call 9-1-1.

For small spills, Proceed only if injury to yourself or others is unlikely and it is neither an emergency nor likely to become an emergency. If properly trained use appropriate spill containment and extinguishing procedures.

Chemical Spill on Body or Clothes – Remove clothing and rinse body or affected skin with plenty of water or thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to "Injuries and Medical Treatment" Flipchart posted in the laboratory.

7. DECONTAMINATION

If there are incidental drips of diethyl ether or THF on the fume hood work surface, secure ignition sources and lower the sash to allow for evaporation. If bench paper becomes contaminated, it must be removed, replaced and disposed as hazardous waste.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person/laboratory during its generation and until disposition.

- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with Peroxide Forming chemicals requires the following prior to beginning work:

1. Must be pre-approved by the Principal Investigator prior to use and all training must be well documented.
2. Must be familiar with the UC Riverside Chemical Hygiene Plan.
3. Must have documented Chemical and Laboratory Safety training and specific training on the techniques and processes to be used.
4. Must read the relevant Safety Data Sheet (formerly referenced as Material Safety Data Sheets).
5. Must demonstrate competence to perform work.
6. When there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs, a review of this SOP and re approval is required.

The Principal Investigator must be notified and approval obtained if diethyl ether will be heated above room temperature or if the solvent volume will be reduced under reduced pressure (rotary evaporation technique). This is a very hazardous process and concentration of the diethyl ether could cause crystals of potentially explosive ethereal peroxides to form. Consult with the Principal Investigator for alternative methods for reducing solvent volume.

10. DESIGNATED AREA

Work should be completed in a laboratory fume hood.

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

Review R.J. Kelly's paper *Review of Safety Guidelines for Peroxidizable Organic Chemicals* (Journal of Chemical Health and Safety; Sept/Oct 1996).

12. DETAILED PROTOCOL

All laboratory personnel using the class of chemicals listed in Section 2 must review this SOP and sign the associated training sheet. Laboratory personnel must have specific hands-on training on the proper handling of Peroxide forming Chemicals and understanding the hazards.

Laboratory personnel using Peroxide forming Chemicals must demonstrate competence to the Principal Investigator or designee by being able to 1) list the foreseeable emergency situations, 2) describe the proper response to the emergency situations, and 3) know the control measures to minimize the risks.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document), and
4) discuss ALL issues or concerns regarding this acid solutions with the PI prior to its use.

If there is an unusual or unexpected occurrence when using the Peroxide forming Chemicals, the occurrence must be documented and discussed with the Principal Investigator or laboratory supervisor and others who might be using acid solutions. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name

Signature

Approval Date: 02/01/2013

PYROPHORIC CHEMICALS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

Researchers should not use pyrophoric reagents until they have read and fully understood these safe operating procedures. However, reading these procedures does not substitute for hands-on training. New users of pyrophoric reagents must work under the close supervision of an experienced user.

1. HAZARD OVERVIEW

In general these materials are pyrophoric; they ignite spontaneously when exposed to air. They also tend to be associated with flammable solvents. Other common hazards include corrositivity, water reactivity, peroxide formation, toxicity, and damage to the liver, kidneys, and central nervous system.

2. SCOPE

A variety of liquid reagents are pyrophoric (spontaneously ignite in air) including (but not necessarily limited to):

Alkyllithium reagents
(Typically in hydrocarbon solvents, *Tert*-butyllithium is VERY pyrophoric)
Alkenyllithium and Aryllithium reagents (Typically in hydrocarbon solvents)
Alkynyllithium reagents (Typically in hydrocarbon solvents)
Grignard Reagents (RMgX) (Typically in hydrocarbon solvents)
Alkylaluminum reagents
(Neat or in hydrocarbon solvents, Neat reagents are VERY pyrophoric)
Alkylzinc reagents (Neat reagents are pyrophoric)
Boranes (Neat reagents are pyrophoric)

3. CONTROLLERING THE HAZARD

BEFORE working with pyrophoric reagents, 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. Set up your work in a laboratory fume hood or glove box and ALWAYS wear the appropriate PPE

4. PHAZARDSERSONAL PROTECTIVE EQUIPMENT (PPE)

a. 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.

b. Skin and Body Protection

A fire resistant lab coat must be worn.
A chemical-resistant apron worn over the lab coat is required for working with large quantities.
No open toe shoes are allowed.

c. Hand 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. Use adequate protection to prevent skin exposures. Heavy gloves are required for work with large quantities.

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

5. DESIGNATED WORK AREA

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

- Eyewash: Suitable facilities for quick drenching or flushing of the eyes should be within 10 seconds travel time for immediate emergency use. Bottle type eyes wash 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: EMany pyrophoric chemicals release noxious or flammable gasses 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 the release of flammable vapors into the laboratory.
- Fire Extinguisher: A Class C dry chemical fire extinguisher must be available within 10 seconds travel time from where pyrophoric chemicals are used. Know the location of the nearest Class D fire extinguisher. A container of powdered lime

(calcium oxide, CAO) should be kept within arm's length when working with a pyrophoric material.

- Glove (dry) box: Glove boxes are an excellent device to control pyrophoric chemicals when inert or dry atmosphere are required.

6. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Handling Pyrophoric Solid Reagents

- Pyrophoric solids are ideally used in a sealed glove box flushed with inert gas.
- Many pyrophoric solids are sold as solutions, or dispersions in mineral oil or are covered with hydrocarbon solvents to facilitate use.
- Mildly pyrophoric solids (such as lithium aluminum hydride and sodium hydride) may be handled in the air for brief periods of time, but the containers must be flushed with inert gas before storage.

Transferring and Weighing Pyrophoric Liquid Reagents

- Gather all necessary experimental equipment first to avoid prolonged exposure of pyrophoric solids to air.
- Weighing alkali metals: Cut desired piece of alkali metal under packing oil using a knife. Using tweezers, transfer to adjacent flask containing toluene or heptane to rinse off oil. Use tweezers again to transfer to a weighed flask of toluene and measure weight to determine mass of metal. Use tweezers again to transfer to desired reaction flask.
- AVOID low boiling rinses such as ether and pentane that tend to condense water upon evaporation.

Storage

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

Disposal of Pyrophoric Liquid Reagents by Quenching

- Small amounts of unused or unwanted pyrophoric materials must be destroyed by careful quenching of the residue. Transfer the materials to an appropriate reaction flask for hydrolysis and/or neutralization. Dilute significantly with an unreactive solvent such as heptane or toluene and place the flask in an ice water cooling bath. Slowly add isopropanol to quench pyrophoric materials. Upon completion, add methanol as a more reactive quenching agent to ensure

completion. Finally, add water dropwise to make sure there are no pockets of reactive materials. Dispose of as hazardous waste.

- Alternatively, reactive substances can be quenched by slowly adding the dilute solution to dry ice, then adding a mildly reactive quenching agent such as methanol.
- AVOID low boiling diluents such as ether and pentane that tend to condense water upon evaporation.
- Do not leave containers with residues of pyrophoric materials open to the atmosphere due to uncontrolled ignition.

Disposal of Pyrophoric Liquid Reagents by Submitting to EHS as Hazardous Waste

- Larger quantities of pyrophoric liquid chemicals can be disposed of as hazardous waste.
- Carefully package and label the wastes.
- Specifically Alert EH&S personnel at the collection location to the hazards of any wastes containing pyrophoric liquid chemicals.

7. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Spill - Large

- Exert extreme caution due to potential spontaneous combustion.
- Exert extreme caution due to potential ignition of flammable solvents or other materials.
- If anyone is exposed, or on fire, wash with copious amounts of water, ideally in the lab shower.
- Call 911 for emergency assistance.
- Evacuate the spill area.
- Post someone or mark-off the hazardous area with tape and warning signs to keep other people from entering.
- Provide emergency personnel with technical advice on the chemicals involved.

Spill - Small

- Exert extreme caution due to potential spontaneous combustion.
- Exert extreme caution due to potential ignition of flammable solvents or other materials.
- If anyone is exposed, or on fire, wash with copious amounts of water, ideally in the lab shower.
- Call for a coworker to provide backup.
- Place a fire extinguisher nearby.

- Carefully remove nearby flammable materials.
- Powdered lime (calcium oxide, CaO) or dry sand should be used to completely smother and cover any spill that occurs.
- Carefully quench by slow addition of isopropanol.
- After complete quench, double bag spill residues for hazardous waste pickup.
- Call 911 for emergency assistance if necessary.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to "Injuries and Medical Treatment" Flipchart posted in the laboratory.

8. DECONTAMINATION

Wear proper PPE, decontaminate equipment and bench tops using soap and water. Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

9. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

10. PRIOR APPROVAL/REVIEW REQUIRED

All work with a pyrophoric chemical must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.

- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

11. DESIGNATED AREA

Work should be completed in a laboratory fume hood or a vacuum system designated for a pyrophoric chemical.

12. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

13. DETAILED PROTOCOL

All lab workers who will be using a pyrophoric chemical must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of a pyrophoric chemical and understand the hazards.

Lab workers using a pyrophoric chemical must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedent for reaction conditions that have reasonable similarities to new chemistry that is planned with a pyrophoric chemical described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) employ < 10 mL of this pyrophoric chemical in any given reaction (larger quantities REQUIRE the approval of PI or designee), and

5) discuss ALL issues or concerns regarding this pyrophoric chemcial with the PI prior to its use.

If there is an unusual or unexpected occurrence when using a pyrophoric chemical, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using a pyrophoric chemcial. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name


Signature

Approval Date: 03/01/2014

Regulated Carcinogens
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

There are a total of 24 regulated carcinogens. Increased recognition of the hazards associated with the transportation, operation, and storage of these materials is essential..

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

Regulated carcinogens are chemicals that cause cancer or tumor development, typically after repeated or chronic exposure. Their effects may only become evident after a long latency period and may cause no immediate harmful effects.

1. Acetylaminofluorene, 2-
2. Acrylonitrile
3. Aminodiphenyl, 3-
4. Arsenic, inorganic (specify compounds)
5. Asbestos (specify material)
6. Benzene
7. Benzidine (and its salts)
8. Bis-chloromethyl ether
9. Coke oven emmissions
10. Dibromo-3-chloropropane, 1,2-
11. Dichlorobenzidine, 3,3'-
12. Dimethylaminoazobenzene, 4-
13. Ethylene dibromide
14. Ethylene oxide
15. Ethyleneimine
16. Formaldehyde
17. Methyl chloromethyl ether
18. 4,4'-Methylene bis-(2-chloroaniline)
19. Alpha-naphthylamine
20. Beta-naphthylamine
21. Nitrobiphenyl, 4-
22. N-Nitroso dimethylamine
23. Beta-propiolactone
24. Vinyl chloride

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the Principal Investigator to ensure that any additional PPE

requirements are identified and communicated to research staff. Contact EH&S for consultation.

a. Eye Protection

ANSI compliant safety glasses with side shields should be worn. Chemical splash goggles should be worn when working with larger quantities. If chemical has a skin hazard or is a caustic liquid, a face shield should be worn when splashing onto the face is a possibility.

b. Skin and Body Protection

Wear chemical resistant lab coat, long pants, and closed-toe shoes. 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.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

Flame-resistant lab coat will be required, if working with pyrophoric chemicals.

c. Hand Protection

At a minimum, wear a chemical-resistant glove. Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

4. ENGINEERING/VENTILATION CONTROLS

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Wash thoroughly after handling. Do not ingest or inhale nor get in eyes, skin or clothing. Remove contaminated clothing and wash before reuse.

Store carcinogens in select designated area, in a tightly closed, labeled container and in a cool, dry well-ventilated area. Segregate from incompatible materials. Secondary containers must be labeled clearly. Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

- *Small* – If you have training, use appropriate personal protective equipment and clean-up materials for chemical spilled. Double bag spill waste in clear plastic bags, label, and arrange for chemical waste pick-up.
- *Large*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

Chemical Spill on Body or Clothes – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to “Injuries and Medical Treatment” Flipchart posted in the laboratory.

7. DECONTAMINATION

Wear proper PPE, decontaminate equipment and bench tops using soap and water. Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.

- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with Regulated Carcinogens must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

Work should be completed in a laboratory fume hood designated for Regulated Carcinogens.

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

12. DETAILED PROTOCOL

All lab workers who will be using Regulated Carcinogens must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of Regulated Carcinogens and understand the hazards.

Lab workers using Regulated Carcinogens must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek

literature precedent for reaction conditions that have reasonable similarities to new chemistry that is planned with Regulated Carcinogen described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) employ < 10 mL of any Regulated Carcinogen in any given reaction (larger quantities REQUIRE the approval of PI or designee), and
5) discuss ALL issues or concerns regarding this Regulated Carcinogens with the PI prior to its use.

If there is an unusual or unexpected occurrence when using this material(s), the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Regulated Carcinogens. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name

Signature

Approval Date: 11/01/2013

HANDLING REPRODUCTIVE HAZARDS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

There are broad spectrums of chemicals that pose the potential to be a reproductive hazard. Increased recognition of the hazards associated with the transportation, operation, and storage of these materials is essential.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

These chemicals have been identified as a reproductive hazard by the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Reproductive hazards are substances or agents that may have adverse effects on various aspects of reproduction including fertility, gestation/pregnancy, birth defects, lactation, genetic effects, general reproductive performance, and can affect both women and men.

Follow prudent lab safety practices when using these chemicals. Consult with EH&S if you have any questions.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

a. Eye Protection

ANSI compliant safety glasses with side shields should be worn. Chemical splash goggles should be worn when working with larger quantities. If chemical has a skin hazard or is a caustic liquid, a face shield should be worn when splashing onto the face is a possibility.

b. Skin and Body Protection

Wear chemical resistant lab coat, long pants, and closed-toe shoes. 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.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

Flame-resistant lab coat will be required, if working with pyrophoric chemicals.

c. Hand Protection

At a minimum, wear a nitrile chemical-resistant glove. Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

4. ENGINEERING/VENTILATION CONTROLS

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Wash thoroughly after handling. Do not ingest or inhale nor get in eyes, skin or clothing. Remove contaminated clothing and wash before reuse.

Store in a tightly closed, labeled container and in a cool, dry well-ventilated area. Segregate from incompatible materials. Secondary containers must be labeled clearly. Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

- *Small* – If you have training, use appropriate personal protective equipment and clean-up materials for chemical spilled. Double bag spill wastes in clear plastic bags, label, and arrange for chemical waste pick-up.
- *Large*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

Chemical Spill on Body or Clothes – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to "Injuries and Medical Treatment" Flipchart posted in the laboratory.

7. DECONTAMINATION

Wear proper PPE, decontaminate equipment and bench tops using soap and water. Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with a reproductive hazard must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

Work should be completed in a laboratory fume hood designated for a reproductive hazard.

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

12. DETAILED PROTOCOL

All lab workers who will be using a reproductive hazard must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of a reproductive hazard and understand the hazards.

Lab workers using a reproductive hazard must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedent for reaction conditions that have reasonable similarities to new chemistry that is planned with Reproductive Hazards Chemicals described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) employ < 100 g of this reproductive hazard in any given reaction (larger quantities REQUIRE the approval of PI or designee), and
5) discuss ALL issues or concerns regarding this with the PI prior to its use.

If there is an unusual or unexpected occurrence when using Reproductive Hazard Chemicals, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using a reproductive hazard. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera	
Print name	Signature

Approval Date: 02/01/2013

STRONG OXIDIZING AGENTS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

Strong Oxidizing Agents generally create a hazard when combined with other materials. There are four categories of strong oxidizers, divided by the severity of risk when mixed with other compounds:

- A material that may increase the burn rate of another material.
- A material that will moderately increase the burn rate.
- A material that will cause a severe increase in burn rate.
- A material that has the potential to lead to an explosive oxidation with combined with other materials.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

Common groups of strong oxidizing agents:

- Class 1: Metal salts of chromates and dicromates, chlorates and perchlorates, nitrates, peroxides, and perborates. Non-salts such as Perchloric acid (below 70% conc.) and hydrogen peroxide (8-27% conc.).
- Class 2: Salts of hypochlorite, permanganate, and peroxide. Non-salts such as chromium trioxide, hydrogen peroxide (27-52%), and nitric acid (>70%).
- Class 3: Ammonium dichromate, potassium chlorate, hydrogen peroxide (55-91%), calcium hypochlorite, sodium chlorate, perchloric acid (60-72%), sodium chlorite (>40%), and potassium bromate.
- Class 4**:** Ammonium perchlorate, ammonium permanganate, guanidine nitrate, hydrogen peroxide (>92%), perchloric acid (>72%), and potassium superoxide.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, the following PPE must be worn at all times:

a. Eye Protection

- Safety glasses with side shields or splash goggles that meet the ANSI Z.87.1 1989 standard.
- When there is the potential for splashes, goggles must be worn.
- Ordinary prescription glasses will NOT provide adequate protection unless they also meet this standard and have compliant side shields.
- Face shields must only be used over either safety spectacles or goggles (for face protection).

b. Skin and Body Protection

- Wear a flame-resistant lab coat. Laboratory coats must be appropriately sized for the individual.
- Laboratory coat sleeves must be fully extended sleeves to the wrists to prevent skin exposure while wearing gloves.
- Laboratory coats must be fully buttoned at all times.
- A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.
- Synthetic clothing such as nylon should not be worn.
- Legs must be covered.
- Close-toed and closed-heel shoes must be worn.

c. Hand Protection

When handling hazardous chemicals or contacting potentially contaminated surfaces, protective gloves are to be worn. For proper selection of glove material, review chemical Safety Data Sheet (SDS) and glove selection guidance on the EH&S web page.

Wear gloves to prevent skin exposure. In a glove box, use the glove box gloves and sleeves. If this chemical is handled in a closed system in a certified fume hood, use appropriate chemical resistant gloves.

NOTE: Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the specific pyrophoric material.

Refer to glove selection chart from the links below:

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

Never re-use disposable gloves, such as nitrile.

If there is a risk of explosion, Kevlar gloves must be worn.

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the PI to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

d. Hygiene Measures

Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

4. ENGINEERING/VENTILATION CONTROLS

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

The following is a general plan for all strong oxidizers:

Always use strong oxidizers in a certified chemical fume hood to minimize the potential for the spread of a fire if one should occur. Have a fire extinguisher at hand (not just hanging on the wall in a distant part of the laboratory) when working with Class 2-4 materials. It is recommended to avoid the use of Class 4 oxidizers. If no alternative can be found, then operations MUST be carried out in a fume hood with the addition of a blast shield. No part of the body (for example, hands) should ever be directly exposed to these materials when they are mixed with other chemicals.

Perchloric acid has a notorious history of causing unanticipated explosions. Perchloric acid can form explosive salts almost anywhere, including in the exhaust ducts of fume hoods and even laboratory benches where other materials have been spilled in the past. Many perchlorate salts are shock sensitive and can lay dormant for very long periods.

For these reasons, it is imperative that perchloric acid only be used in a perchloric acid designated fume hood that is not used for any other function. Spills should be immediately and thoroughly cleaned up. This fume hood shall be prominently marked as for use ONLY with perchloric acid and no other materials. EH&S should be contacted for proper signage and approvals. Keep in mind that only a new fume hood can be designated for perchloric acid use.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

The following administrative controls must be followed:

- Never work alone. At least one other person must be present in the same laboratory when any work involving strong oxidizers is carried out.
- Eliminate or substitute a less hazardous material when possible.
- Design your experiment to use the least amount of material possible to achieve the desired result.
- It is better to do multiple transfers of small volumes than attempt to handle larger quantities. Finely divided solids must be transferred under an inert atmosphere in a glove box. Liquids may be safely transferred without a glove-box by employing certain syringe techniques and equipment. Before transferring, make sure that the material is at room temperature.
- Verify your experimental set-up and procedure prior to use.

- Inform colleagues that this material will be used and where. Label the work area with a sign saying "Strong Oxidizing Agent Use Area."
- Only use if the area is properly equipped with a certified eye wash/safety shower within ten seconds of travel.
- Ensure that all use details are recorded in a log book which notes the date, user, amount used, and current quantity on hand.
- Consult with the campus Chemical Hygiene Officer if work involves large quantities.

It is essential that all strong corrosives be stored separately from all chemicals with which they may react. Ensure secondary containment and segregation of incompatible chemicals per guidance within the UC Riverside Chemical Hygiene Plan. Also, follow any substance-specific storage guidance provided in Safety Data Sheet (SDS) documentation.

Wash thoroughly after handling. Do not ingest or inhale nor get in eyes, skin or clothing. Remove contaminated clothing and wash before reuse.

Store in a tightly closed, labeled container and in a cool, dry well-ventilated area. Segregate from incompatible materials. Secondary containers must be labeled clearly. Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

If there is an unusual or unexpected occurrence when using Strong Oxidizing Agents, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Strong Oxidizing Agents. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

Spills should be immediately and thoroughly cleaned up. Proceed only if you will not injure yourself or others and it is not an emergency and not likely to become an emergency. Work areas should be demarked with an indicator that strong oxidizing materials are in use or exposed. Keep a chemical spill kit easily accessible. In the case

of strong oxidizing agents, consider the likelihood of fire. If you are unsure about how to clean up a spill, contact EH&S for help.

- *Small* – If you have training, use appropriate personal protective equipment and clean-up materials for chemical spilled. Double bag spill waste in clear plastic bags, label, and arrange for chemical waste pick-up.
- *Large*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

  a) Use extreme caution due to potential ignition of flammable solvents or other materials.
  b) Evacuate the spill area. Post someone or mark-off the hazardous area with tape and warning signs to keep other people from entering the area.
  c) Contact EH&S if you have any concerns about how to manage a spill no matter how large or small.
  d) Review the EH&S Emergency Guide before beginning work.
  e) Keep the appropriate fire extinguisher nearby.
  f) Keep a chemical spill kit easily accessible. Do not use organic based absorbents such as sawdust, especially with perchloric acid.

Chemical Spill on Body or Clothes – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to “Injuries and Medical Treatment” Flipchart posted in the laboratory.

7. DECONTAMINATION

Wear proper PPE. Carefully inspect work areas to make sure no materials remain. Be sure all ignition sources are secured before beginning cleaning up with flammable liquids. Decontaminate equipment and bench tops using wipers moistened with dry, non-polar solvent (hexane). Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Label all waste with the chemical contents and the appropriate hazard warning.
- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with strong oxidizers requires the following prior to beginning work:

1) Must be pre-approved by the Principal Investigator prior to use and all training must be well documented.
2) Must be familiar with the UC Riverside Chemical Hygiene Plan.
3) Must have documented Chemical and Laboratory Safety training, and specific training on the techniques and processes to be used.
4) Must read the relevant Safety Data Sheet (formerly referenced as Material Safety Data Sheets).
5) EH&S must be consulted in advance if any work involves the heating of perchloric acid.
6) Must demonstrate competence to perform work.
7) Must read Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards (section 3.D.2.3 - 3.D.3.3 Incompatible Chemicals - Other Oxidizers) - http://www.nap.edu/openbook.php?record_id=4911&page=51
8) When there are any changes to procedures, personnel, equipment, or when an incident or near-miss occurs, a review of this SOP and re-approval is required. A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

Work should be completed in a laboratory fume hood designated for Strong Oxidizing Agents.

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

12. DETAILED PROTOCOL

All lab workers who will be using strong oxidizing agents must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of and understand the hazards.

Lab workers using a strong oxidizing agents must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, cannula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedent for reaction conditions that have reasonable similarities to new chemistry that is planned with strong oxidizing agents described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone

2) be cognizant of all of the SDS and safety information presented in this document

3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document)

4) employ < 10 mL of this a strong oxidizing agents in any given reaction (larger quantities REQUIRE the approval of PI or designee)

5) discuss ALL issues or concerns regarding a strong oxidizing agents with the PI prior to its use.

If there is an unusual or unexpected occurrence when using Strong Oxidizing Agents the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using a strong oxidizing agents. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera	
Print name	Signature

Approval Date: 02/01/2013

UC RIVERSIDE UNIVERSITY OF CALIFORNIA

STRONG REDUCING AGENTS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

Reductants in chemistry are very diverse. They must be protected, of course, from any inadvertent reaction with oxidizing agents. Strong reductants include the electropositive elemental metals, such as lithium, sodium, magnesium, iron, zinc, and aluminum, even more so when finely divided. These metals donate or give away electrons readily. Hydride transfer reagents, such as $NaBH_4$ and $LiAlH_4$, are widely used in organic chemistry primarily in the reduction of carbonyl compounds to alcohols. Alkyl-metal compounds may be viewed as strong reductants, most are extremely water reactive and in several cases are even considered to be pyrophoric. Another example of a reducing agent involves the use of hydrogen gas (H_2) with a palladium, platinum, or nickel catalyst.

Finally, materials of known reducing potential, such as hydrazine, should also be considered. Many such agents may be better characterized as water reactives, pyrophorics, or by their other major hazardous characteristics.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

Common groups of strong reducing agents:

- Electropositive elemental metals: lithium, sodium, potassium, magnesium, iron, zinc, and aluminum
- Hydride transfer reagents: $NaBH_4$ and $LiAlH_4$
- Alkyl-metal compounds

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

At a minimum, the following PPE must be worn at all times:

a. Eye Protection

- Safety glasses with side shields or splash goggles that meet the ANSI Z.87.1 1989 standard.
- When there is the potential for splashes, goggles must be worn.
- Ordinary prescription glasses will NOT provide adequate protection unless they also meet this standard and have compliant side shields.
- Face shields must only be used over either safety spectacles or goggles (for face protection).

b. Skin and Body Protection

- Wear a flame-resistant lab coat. These laboratory coats must be appropriately sized for the individual.
- Fully extend sleeves to the wrists. Laboratory coat sleeves must be of a sufficient length to prevent skin exposure while wearing gloves.
- Buttoned at all times. Must be buttoned to their full length.
- Non-synthetic clothing (e.g., nylon) should be worn.
- Wear long pants, covered legs.
- Closed-toe, closed heel shoes.
- A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

c. Hand Protection

- When handling hazardous chemicals or contacting potentially contaminated surfaces, protective gloves are to be worn. For proper selection of glove material, review chemical Safety Data Sheet **(SDS)** and glove selection guidance on the **EH&S** web page
- Wear gloves to prevent skin exposure. In a glove box, use the glove box gloves and sleeves. If this chemical is handled in a closed system in a certified fume hood, use appropriate chemical resistant gloves.
- Never re-use disposable gloves, such as nitrile.
- If there is a risk of explosion, Kevlar gloves must be worn.

NOTE: Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the specific pyrophoric material.

Refer to glove selection chart from the links below:

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or http://www.showabestglove.com/site/default.aspx

Additional PPE may be required if procedures or processes present additional risk. It is the responsibility of the Principal Investigator to ensure that any additional PPE requirements are identified and communicated to research staff. Contact EH&S for consultation.

d. Hygiene Measures

Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

4. ENGINEERING/VENTILATION CONTROLS

The following is a general plan for all strong reducing agents:

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

Always use strong reducing agents in a certified chemical fume hood to minimize the potential for the spread of a fire if one should occur.

Have an appropriate fire extinguisher at hand (not just hanging on the wall in a distant part of the laboratory) when working with this class of materials.

Where available, an inert atmosphere glove box can drastically reduce the chance of inadvertent fire or exposure. If no alternative can be found, then operations MUST be carried out in a fume hood with the addition of a blast shield.

No part of the body (for example, hands) should be directly exposed to these materials as they are being mixed with other chemicals.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

The following administrative controls must be followed:

- Never work alone. At least one other person must be present in the same laboratory when any work involving strong oxidizers is carried out.
- Eliminate or substitute a less hazardous material when possible.
- Design your experiment to use the least amount of material possible to achieve the desired result.
- It is better to do multiple transfers of small volumes than attempt to handle larger quantities. Finely divided solids must be transferred under an inert atmosphere in a glove box. Liquids may be safely transferred without a glove-box by employing certain syringe techniques and equipment. Before transferring, make sure that the material is at room temperature.
- Verify your experimental set-up and procedure prior to use.
- Clear the hood or work area of strong oxidants, incompatibles, or other extraneous equipment and materials.
- Inform colleagues that this material will be used and where. Label the work area with a sign saying "Strong Reducing Agent Use Area".
- Only use if the area is properly equipped with a certified eye wash/safety shower within ten seconds of travel.
- Consult with the campus Chemical Hygiene Officer if work involves large quantities.

It is essential that all strong reducing agents be stored separately from all chemicals with which they may react, in particular, from any oxidizing agents. Ensure secondary containment and segregation of incompatible chemicals per guidance within the UC Riverside Chemical Hygiene Plan. Also, follow any substance-specific storage guidance provided in Safety Data Sheet (SDS) documentation.

Wash thoroughly after handling. Do not ingest or inhale nor get in eyes, skin or clothing. Remove contaminated clothing and wash before reuse.

Store in a tightly closed, labeled container and in a cool, dry well-ventilated area. Segregate from incompatible materials. Secondary containers must be labeled clearly. Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

Use small quantities whenever possible. Monitor your inventory closely to assure that you have tight control over your material.

6. SPILL AND INCIDENT PROCEDURES

Spills should be immediately and thoroughly cleaned up. Proceed only if you will not injure yourself or others and it is not an emergency and not likely to become an emergency. Work areas should be demarked with an indicator that strong reducing materials are in use or exposed. Keep a chemical spill kit easily accessible. In the case of strong reducing agents, consider the likelihood of fire.

Once spilled, all liquid or solid pyrophoric chemicals will instantly ignite.

If you are unsure about how to clean up a spill, contact EH&S for help.

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

- *Small* – If you have training, use appropriate personal protective equipment and clean-up materials for chemical spilled. Double bag spill waste in clear plastic bags, label, and arrange for chemical waste pick-up.
- *Large*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

- Use extreme caution due to potential ignition of flammable solvents or other materials.

- Evacuate the spill area. Post someone or mark-off the hazardous area with tape and warning signs to keep other people from entering the area.
- Contact EH&S if you have any concerns about how to manage a spill no matter how large or small.
- Review the EH&S Emergency Guide before beginning work.
- Keep the appropriate fire extinguisher nearby.
- Keep a chemical spill kit easily accessible.

Chemical Spill on Body or Clothes – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to "Injuries and Medical Treatment" Flipchart posted in the laboratory.

7. DECONTAMINATION

Carefully inspect work areas to make sure no materials remain. Wear proper PPE. Clean contaminated work areas, equipment, and bench tops with wipers moistened with dry, non-polar solvent (hexane). Be sure all ignition sources are secured before beginning cleaning up with flammable liquids.

Dispose of all used contaminated disposables as hazardous waste following the Waste Disposal Section.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.

- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with Strong Reducing Agents requires the following prior to beginning work:

- Must be pre-approved by the Principal Investigator prior to use and all training must be well documented.
- Must be familiar with the UC Riverside Chemical Hygiene Plan.
- Must have documented Chemical and Laboratory Safety training, and specific training on the techniques and processes to be used.
- Must read the relevant Safety Data Sheet (formerly referenced as Material Safety Data Sheets).
- Must demonstrate competence to perform work.
- When there are any changes to procedures, personnel, equipment, or when an incident or near-miss occurs, a review of this SOP and re-approval is required.
- A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

DESIGNATED AREA

Work should be completed in a laboratory fume hood designated for Strong Reducing Agents.

SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

DETAILED PROTOCOL

All lab workers who will be using Strong Reducing Agents must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of Strong Reducing Agents and understand the hazards.

Lab workers using Strong Reducing Agents must demonstrate competence to the Principal Investigator or designee by being able to 1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.), 2) list the foreseeable emergency situations, 3) describe the proper response to the emergency situations, and 4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedent for reaction conditions that have reasonable similarities to new

chemistry that is planned with Strong Reducing Agents described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

(1) not work alone (if you are alone in the laboratory, leave),

(2) be cognizant of all of the SDS and safety information presented in this document,

(3) find/follow a literature experimental procedure describing the use of this reagent covered by this SOP in a related chemical transformation. If a pertinent literature protocol cannot be found, the researcher MUST discuss the planned experiment with the PI (or designee) prior to using this reagent,

(4) not deviate from the literature experimental protocol mentioned in (3) in either temperature or pressure without PRIOR APPROVAL from the PI (or designee),

(5) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document),

(6) employ < 1 g of this Strong Reducing Agents in any given reaction (larger quantities REQUIRE the approval of PI or designee), and

(7) discuss ALL issues or concerns regarding this reagent with the PI prior to its use.

If there is an unusual or unexpected occurrence when using this material(s), the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Strong Reducing Agents. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name


Signature

Approval Date: 02/01/2013

UC RIVERSIDE UNIVERSITY OF CALIFORNIA

WATER REACTIVE CHEMICALS
STANDARD OPERATING PROCEDURE

Type of SOP: ☐ Process ☐ Hazardous Chemical ☒ Hazard Class

1. HAZARD OVERVIEW

Water reactive materials can react violently with water or atmospheric moisture to produce gas and heat. Typical gases produced are: H_2, CH_4, H_2S, NH_3, PH_3, HCN, HF, HCl, HF, HI, SO_2, and SO_3.

The risks associated with a specific chemical depend on its reactivity and the nature of the gaseous product (flammable, toxic, or both). The mutual production of flammable gas and heat can lead to spontaneous ignition or explosion.

Prior to working with any water reactive chemicals you must identify which gas may be formed in case of exposure to water and learn the risks associated with this gas.

The reaction rate of solid material (and therefore heat and gas generation) depends on the material's surface area. Therefore, smaller particle size increases the hazards associated with these materials.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

Common groups of water reactive materials:

- Grignard reagents: RMgX
- Alkali metals: Li, Na, K
- Alkali metal amides
- Alkali metal hydrides: Lithium aluminum hydride
- Metal alkyls: Lithium and aluminum alkyls
- Chlorosilanes
- Halides of nonmetals: BCl_3, BF_3, PCl_3, PCl_5, $SiCl_4$, S_2Cl_2
- Inorganic acid halides: $POCl_3$, $SOCl_2$, SO_2Cl_2
- Anhydrous metal halides: $AlCl_3$, $AlBr_3$, $TiCl_4$, $ZrCl_4$, $SnCl_4$
- Organic acid halides and anhydrides of low molecular weight

Water reactive material may also present additional hazards such as corrosivity or toxicity.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

a. Eye Protection

ANSI compliant safety glasses with side shields should be worn. Chemical splash goggles should be worn when working with larger quantities. If chemical has a skin hazard or is a caustic liquid, a face shield should be worn when splashing onto the face is a possibility.

b. Skin and Body Protection

Wear flame-resistant lab coat, long pants, and closed-toe shoes. 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.

A chemical resistant apron should be used when transferring or using large quantities and splashing is a possibility.

Flame-resistant lab coat will be required, if working with pyrophoric chemicals.

c. Hand Protection

At a minimum, wear a chemical-resistant glove. Consult with your preferred glove manufacturer to ensure that the gloves you plan on using are compatible with the chemical and usage.

http://www.ansellpro.com/download/Ansell_8thEditionChemicalResistanceGuide.pdf or

http://www.showabestglove.com/site/default.aspx

4. ENGINEERING/VENTILATION CONTROLS

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.

The following is a general plan for all water reactive materials:

- Work under an inert atmosphere (argon, nitrogen) in a glove box.
- Be sure to have a quenching scheme for residual materials prior to beginning work in the glove box.

If work in a glove box is impractical or otherwise not indicated:

- Work in a properly functioning certified chemical fume hood when handling water reactive materials. Work with the sash at the certified position or lower. The hood flow alarm should be checked to be operating correctly prior to using the hood.
- Work away from water source or potential water splash.
- Use fresh dry solvents.
- Work under inert atmosphere (Nitrogen, argon).

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Special Handling Procedures:

1) Design a quenching scheme for residual materials prior to using water reactive materials. Never use water to quench the material itself or a reaction where a water-reactive reagent is used. Begin quenching with a low reactivity quenching

agent and slowly add more reactive quenching agents. For example, first quench residual sodium metal with isopropanol and then add ethanol to the mixture.

2) Never work alone. At least one other person must be present in the same laboratory when any work involving water reactive material is carried out. Notify the person about your plans to use water reactive material.
3) Eliminate or substitute a less hazardous material when possible.
4) Design your experiment to use the least amount of material possible to achieve the desired result.
5) It is better to do multiple transfers of small volumes than attempt to handle larger quantities. Finely divided solids must be transferred under an inert atmosphere in a glove box. Liquids may be safely transferred without a glove-box by employing certain syringe techniques and equipment. Before transferring, make sure that the material is at room temperature.
6) Verify your experimental set-up and procedure prior to use.
7) Inform colleagues that this material will be used and where. Label the work area with a sign saying "Water Reactives Use Area".
8) Only use if the area is properly equipped with a certified eye wash/safety shower within ten seconds of travel.
9) Consult with the campus Chemical Hygiene Officer if work involves large quantities.
10) Never use water to extinguish fires caused by water reactive materials.

Storage Requirements:

1) Minimize your purchases to only what is needed in a reasonable amount of time. Use small quantities whenever possible.
2) Store in a separate secondary container and label the material clearly. Also, follow any substance-specific storage guidance provided in Safety Data Sheet documentation.
3) Store in a cool, dry location, separated from acids.
4) Monitor your inventory closely to assure that you have tight control over your material.
5) Wash hands and arms with soap and water after handling.
6) Minimize dust generation and accumulation.
7) Area: At the end of each project, thoroughly inspect the area for residual reactive material.

6. SPILL AND INCIDENT PROCEDURES

Chemical Spill - Dial 911 and EH&S 951-827-5528

Assess the extent of danger. Help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors. If possible, confine the spill to a small area using a spill kit or absorbent material. Keep others from entering contaminated area (e.g., use caution tape, barriers, etc.).

- *Small* – If you have training, use appropriate personal protective equipment and clean-up materials for chemical spilled. Double bag spill waste in clear plastic bags, label, and arrange for chemical waste pick-up.
- *Large*– Dial 911 and EH&S at 951-827-5528 for assistance. Notify others in area of spill. Turn off ignition sources in area. Evacuate area and post doors to spill area. Remain on the scene, but at a safe distance, to receive and direct safety personnel when they arrive.

Chemical Spill on Body or Clothes – Remove clothing and rinse body thoroughly in emergency shower for at least 15 minutes. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Chemical Splash Into Eyes – Immediately rinse eyeball and inner surface of eyelid with water from the emergency eyewash station for 15 minutes by forcibly holding the eye open. Seek medical attention. Notify supervisor and EH&S at 951-827-5528 immediately.

Medical Emergency - Dial 911 and EH&S 951-827-5528

Refer to “Injuries and Medical Treatment” Flipchart posted in the laboratory.

7. DECONTAMINATION

Water reactive by-products and residual feedstock that remains water reactive must be quenched before presenting for hazardous waste pick up.

Carefully inspect work areas to make sure no reactive materials remain. Clean contaminated work areas with wipes moistened with dry, non-polar solvent (hexane). Be sure all ignition sources are secured before beginning cleaning up with flammable liquids.

8. WASTE DISPOSAL

All waste must be disposed through the EH&S Hazardous Waste Program. Do not present waste that remains water reactive for pick up. Quench reactive by-products before requesting hazardous waste pick up.

Do not flush with water. Cover with dry sand or other non-combustible material. Dispose as hazardous waste following the guidelines below.

Staff dealing with hazardous waste disposal should have completed UCR Hazardous Waste Management training - http://ehs.ucr.edu/training/online/hwm/indexlms.html

General hazardous waste disposal guidelines:

- Affix an on-online hazardous waste tag using the Online Tag Program (OTP - https://otp.ucop.edu/) on all waste containers as soon as the first drop of waste is added to the container.
- Store hazardous waste in closed containers, in secondary containment, and in a designated location. Do not let product enter drains. Discharge into the environment must be avoided.
- Double-bag dry waste using transparent bags.
- Waste must be under the control of the person generating and disposing of it.
- Dispose of routinely generated chemical waste within 90 days.
- Request a waste pick-up on-line: http://ehs.ucr.edu/services/waste.html

9. PRIOR APPROVAL/REVIEW REQUIRED

All work with Water Reactive Chemicals must be pre-approved by the Principal Investigator prior to use and all training must be well documented. In addition, the following shall be completed:

- Documented specific training and specific training on the techniques and processes to be used.
- Read and understand the relevant Safety Data Sheet.
- Demonstrate competence to perform work.

A review of this SOP and re-approval is required when there are any changes to procedures, personnel, equipment, or when an incident or near miss occurs.

10. DESIGNATED AREA

Work should be completed in a laboratory fume hood designated for Water Reactive Chemicals.

11. SAFETY DATA SHEETS

Online SDS can be found at http://www.ehs.ucr.edu/services/msds.html.

12. DETAILED PROTOCOL

All lab workers who will be using Water Reactive Chemicals must review this SOP and sign the associated training sheet. Lab workers must have specific training on the proper handling of Water Reactive Chemicals and understand the hazards.

Lab workers using Water Reactive Chemicals must demonstrate competence to the Principal Investigator or designee by being able to

1) identify the hazards and list any particularly hazardous handling techniques (use of a schlenck line, rotary evaporation, canula transfer, extremes of pressure or temperature, etc.),
2) list the foreseeable emergency situations,
3) describe the proper response to the emergency situations, and
4) know the control measures to minimize the risks.

The research laboratory requires variation in reaction conditions to develop and optimize new chemical or biological transformations. The researcher must seek literature precedence for reaction conditions that have reasonable similarities to new chemistry that is planned with Water Reactive Chemicals described in this SOP. The researcher must also consult the PI or designated, experienced research coworker for approval to proceed with chemical or biological transformations that have little literature or local research group precedent. PI approval must also be obtained for significant scale-up (PI defines factor) of new chemistry or biological transformations.

When working in the lab, a laboratory worker must:

1) not work alone;
2) be cognizant of all of the SDS and safety information presented in this document;
3) follow all related SOPs in the laboratory SOP bank (PPE, syringe techniques, waste disposal, etc. as appropriately modified by any specific information in the SDS information presented in this document);
4) employ < 1 g of this Water Reactive Chemicals in any given reaction (larger quantities REQUIRE the approval of PI or designee), and
5) discuss ALL issues or concerns regarding this Water Reactive Chemicals with the PI prior to its use.

If there is an unusual or unexpected occurrence when using Water Reactive Chemicals, the occurrence must be documented and discussed with the Principal Investigator or Lab Supervisor and others who might be using Water Reactive Chemicals. Unusual or unexpected occurrences might include a fire, explosion, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers.

SOP Reviewed and Approved by:

Francisco Zaera
Print name

Signature

Approval Date: 11/01/2013