Standard Operating Procedures

Peroxide Forming Chemicals (PFC) – Class 2

1,4-Dioxane

Print a copy and insert into your laboratory SOP binder.

Department:	Chemistry
Date SOP was written:	June 17, 2013
Date SOP was approved by PI/lab supervisor:	
Principal Investigator:	Name: Richmond Sarpong **Signature: _____**
Internal Lab Safety Coordinator or Lab Manager:	Name: Rebecca Murphy Lab Phone: 510-643-2485 Office Phone: 510-642-6312
Emergency Contact:	Name: Richmond Sarpong Phone Number: 626-644-2407
Location(s) covered by this SOP:	Latimer Hall: 834, 836, 837, 838, 839, 842, 847, 849, 907

1 - Purpose

This SOP covers the precautions and safe handling procedures for the use of 1,4-Dioxane in the Sarpong group, which include the following uses:

Chemical	Use
1,4-Dioxane	1. 1,4-dioxane is used in the lab as a solvent in reactions. 2. Used in the lab as a solvent in column chromatography.

2 - Physical & Chemical Properties/Definition of Chemical Group

CAS#: 123-91-1

Molecular Formula: $C_4H_8O_2$

Form: liquid

Color: colorless

Melting point/freezing point: 10 - 12 °C (50 - 54 °F) - lit.

Boiling point: 100 - 102 °C (212 - 216 °F) - lit.

Vapor pressure: 36 hPa (27 mmHg) at 20 °C (68 °F)

Density: 1.034 g/cm^3 at 25 °C (77 °F)

Flash point: 12 °C (54 °F) - closed cup

Lower explosion limit: 2% (V)

Upper explosion limit: 22% (V)

Odor: no data available

Odor Threshold: no data available

3 - Potential Hazards/Toxicity

GHS Classification

Flammable liquids (Category 2)
Acute toxicity, Oral (Category 5)
Skin irritation (Category 3)
Eye irritation (Category 2A)
Carcinogenicity (Category 2)
Specific target organ toxicity - single exposure (Category 3), Respiratory system

GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)

H225	Highly flammable liquid and vapor.
H303 + H333	May be harmful if swallowed or if inhaled.
H319	Causes serious eye irritation.
H335	May cause respiratory irritation.
H351	Suspected of causing cancer.
H413	May cause long lasting harmful effects to aquatic life.

Precautionary statement(s)

P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P261	Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray.
P281	Use personal protective equipment as required.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

Other hazards

May form explosive peroxides. Repeated exposure may cause skin dryness or cracking.

Cal/OSHA Permissible Exposure Limits (PEL): 0.28 ppm (1.0 mg/m^3) – 8-hour TWA with Skin Notation

4 - Engineering Controls

Use the engineering controls listed below unless other lab-specific information is included in the Protocol/Procedure section.

- A laboratory type fume hood with the sash position closed as much as possible;
- A glove box for pyrophorics and water reactive chemicals. Glove boxes may also be required for other chemicals, such as regulated carcinogens and particularly hazardous substances;

- Supplemental protective equipment like a blast shield, where appropriate, to protect from explosions when using peroxide formers, pyrophorics, water reactives, and potentially explosive chemicals.

5 - Personal Protective Equipment

For additional information on PPE requirements, go to:
http://ccehss.berkeley.edu/section5#Personnel_Protective_Equipment_Required_in_College_Laboratories

Use the PPE listed below unless other lab-specific information is included in the Protocol/Procedure section.

Eye and Face Protection

ANSI-approved safety glasses with side shields or chemical splash goggles must be worn at all times when handling chemicals in the lab.

Skin and Body Protection

1. Gloves are required when handling hazardous chemicals.
    a. Specific glove type recommendations are provided in the Protocol/Procedure section.
    b. Inspect gloves prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Wash and dry hands after handling chemicals, before breaks, and at the end of the workday.
    c. For additional information on glove selection, go to: http://ehs.berkeley.edu/hs/63-laboratory-safety/94-glove-selection-and-usage.html
2. Lab coats are required when handling hazardous chemicals in the lab.
    a. Nomex 3A flame-resistant lab coats are required when working with pyrophorics (H250) and explosives (H200, H201, H202, H203)
    b. Flame resistant lab coats (Nomex or other material) should be worn when working with materials such as Category 1 or 2 flammable liquids (H224 and H225).
3. Cotton-based, non-synthetic clothing (including long pants; no skin exposed below the waist) should be worn.
4. Closed-toe and closed-heel shoes are required in the lab.

Respiratory Protection

Respiratory protection is normally not required for UC Berkeley laboratory activities. Any lab personnel considering the use of a respirator must contact EH&S for a workplace assessment. Respirator users will be provided with specific instructions if a respirator is deemed necessary by EH&S.

6 - First Aid Procedures and Medical Emergencies

Notify supervisor and EH&S immediately. Follow up with a call to 510-642-9090 to report the incident.

Life Threatening Emergency, After Hours, Weekends and Holidays – Call **911** or go to the nearest emergency room. Note: All serious injuries must be reported to EH&S within 8 hours. Follow up with a call to 510-642-9090 to report the incident.

Assess the extent of danger. If you cannot assess the conditions of the environment well enough to be sure of your own safety, do not enter the area. If possible, help contaminated or injured persons. Obtain medical attention for the individual as soon as possible by calling **911**. Provide a copy of the appropriate SDS to the emergency responders or physician, as needed.

If inhaled

Move into fresh air. Go to the Occupational Health Facility (Tang Health Center) and after hours, go to the nearest emergency room. If person is not breathing, call **911** and give artificial respiration. If unconscious, call **911**.

In case of skin contact

Immediately flush with flowing water for no less than 15 minutes; remove any jewelry or clothing as necessary to facilitate clearing of any residual materials. Wash off with soap and plenty of water for 15 minutes. If skin contact requires medical assistance, go to the Occupational Health Facility (Tang Health Center) and after hours, go to the nearest emergency room. If this is a large or serious injury, call **911**.

In case of eye contact

Rinse thoroughly with plenty of water using an eyewash station for at least 15 minutes, occasionally lifting the upper and lower eyelids. Remove contact lenses if possible. Call **911**.

If swallowed

Call **911**. Do not induce vomiting unless directed otherwise by the SDS. Never give anything by mouth to an unconscious person. Rinse mouth with water. Go to the Occupational Health Facility (Tang Health Center) and after hours, go to the nearest emergency room.

Needle stick/puncture exposure

Wash the affected area with antiseptic soap and warm water for 15 minutes. For mucous membrane exposure such as eyes, mouth and/or nose, flush the affected area for 15 minutes using an eyewash station. Go to the Occupational Health Facility (Tang Health Center) and after hours, go to the nearest emergency room.

All needle stick/puncture exposures must be reported to EH&S within 8 hours. Follow up with a call to 510-642-9090 to report the incident.

7 - Special Handling and Storage Requirements

Lab-specific information on handling and storage may be included in the Protocol/Procedure section.

Working alone - Certain extremely hazardous operations should not be performed if the PI or Lab Safety Contact(s) are not present. Never work alone with extremely hazardous materials/operations. See the Protocol/Procedure section below for specific prohibitions (if any) on working alone.

Precautions for safe handling

- Avoid contact with skin and eyes. Avoid formation of vapors, dusts, mists and aerosols.
- Use appropriate exhaust ventilation.
- Use appropriate personal protective equipment.
- Remove incompatible chemicals from immediate work area.
- Keep flammable, pyrophoric, potentially explosive and water reactive chemicals away from sources of ignition
- Use care when preparing chemical solutions.

Conditions for safe storage

- Keep quantities to a minimum.
- Keep containers tightly closed and in a cool, dry and well-ventilated location.
- Keep in proper storage cabinets and shelving. Use lowest shelve possible.
- Assure chemicals are properly labeled.
- Segregate incompatible chemicals.
- Store carcinogens in a designated area.

- Provide secondary containment for chemicals in accordance with the ccEHS "Chemical Hygiene Plan": http://ccehss.berkeley.edu/section5#Chemical_Handling_Storage_and_Transportation

8 - Chemical Spill

Spill – Assess the extent of danger; if necessary request help by calling **911** and 510-642-9090. If you cannot assess the conditions of the environment well enough to be sure of your own safety, do not enter the area. If possible help contaminated or injured persons. Evacuate the spill area. Avoid breathing vapors from spill. 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.).

Minor Spill – In the event of a minor spill, if there is no potential for hazardous chemical exposure, report the spill to 510-642-9090 and proceed to clean it, if you are trained. Use appropriate personal protective equipment and clean-up material for chemical spilled. Double bag spill waste in clear plastic bags, label and take to the next chemical waste pick-up location.

Call 510-642-9090 to report the spill to ccEHSS and for assistance.

Major Spill – Any hazardous chemical spill that involves chemical exposure, any chemical spill that due to size and/or hazard requires capabilities beyond your training, or any chemical spill that gives the perception (because of odor, for example) that there has been a hazardous release

Call **911** and 510-642-9090 to report the spill to ccEHSS and for assistance.

9 - Cleaning and Decontamination

Lab-specific information on decontamination may be included in the Protocol/Procedure section.

- Wearing proper PPE, laboratory work surfaces should be cleaned at the end of each work day.
- Dispose of contaminated materials in accordance with hazardous waste disposal guidelines referenced below.
- Decontaminate all equipment before removing from a designated area.

10 - Hazardous Waste Disposal

Label Waste

Label all containers with the label provided at:
http://ehs.berkeley.edu/hm/279-new-hazardous-waste-program-hwp.html.
See the EH&S Fact Sheet, “Hazardous Waste Management” for general instructions on procedures for disposing of hazardous waste.

Dispose of Waste

- Dispose of regularly generated chemical waste within 6 months.
- Call EH&S with questions.

11 - Safety Data Sheet (SDS) Location

SDS can be accessed online at http://ucmsds.com

12 - Protocol/Procedure – 1,4-Dioxane

Preparation	Know the location of the nearest fire extinguisher, eyewash, and safety shower before beginning work. Never open a dented or otherwise compromised container of 1,4-dioxane. Alert lab safety contact immediately. Never open/use/move a 1,4-dioxane that is suspected to contain peroxides or is in contact with crystals indicative of peroxide formation. Do not touch the crystals. Alert lab safety contact immediately. Eliminate incompatible materials (e.g. oxidizing and reducing agents, halogens and perchlorates) from potential spill area. Eliminate ignition sources such as open flames, hot surfaces, steam baths, and static electricity. Never work alone. Make sure there is another worker present who is also trained in the use of 1,4-dioxane.
Chemical Storage and Disposal	**Storage** Store containers in an approved area, such as a ventilated flammable storage cabinet. Segregate from any incompatible materials, such as oxygen, oxidizing agents, halogens, reducing agents, perchlorates, and trimethylaluminum. Keep containers in a cool, well-ventilated area. Avoid all possible sources of ignition (spark or flame). Protect from flames, static electricity and sources of heat. Prolonged exposure to air and light may form unstable explosive peroxides unless inhibited against peroxide formation. Store and transport containers in secondary containment (for example polyethylene bottle carrier). Keep storage containers closed (air tight) when not in use. Purchase 1,4-dioxane with inhibitors added (for peroxide-forming) when possible. Due to its peroxide-forming hazard, 1,4-dioxane containers must be dated upon receipt and at the time they are opened (mark the date on the bottle). If tested, note the date it was tested on the bottle. Unopened containers of 1,4-dioxane have a maximum shelf life of 18 months. Opened containers of 1,4-dioxane have a maximum shelf life of 12 months. Test open 1,4-dioxane containers with peroxide test strips every 3 months. Dispose of unused amounts after that period of time has passed (or if peroxides are found to be present by testing). Degassed 1,4-dioxane may be stored in resealable Schlenk flasks under an atmosphere of argon or nitrogen, or stored in closed containers in a glove box with a nitrogen or argon atmosphere. **Disposal** 1,4-Dioxane waste is considered hazardous. Collect all liquid waste in labeled 1 gallon plastic containers. Store hazardous waste in closed containers, in secondary containment and in a designated location. Mix ONLY with compatible waste streams, such as other organic solvents.

	Call EH&S with questions.
Lab-specific Information	If being used at a temperature higher than its boiling point (101 ºC), the reaction vessel must be capable of handling the pressure buildup and the use of a blast shield is recommended for all volumes, and required if >50mL dioxane is used. Avoid contact with skin and eyes. Avoid inhalation of vapor or mist. Keep away from sources of ignition (such as Bunsen burners). Take measures to prevent the build-up of electrostatic charge.

Procedure/Use	Scale	Engineering Controls/Equipment	PPE (eye, face, gloves, clothing)	Procedure Steps and Precautions
1. 1,4-dioxane is used in the lab as a solvent in reactions.	Up to *2 L* 1,4-dioxane per reaction.	All work with 1,4-dioxane must be performed in a ventilated fume hood. Keep 1,4-dioxane under an inert atmosphere when not in use. Eliminate ignition sources such as open flames, hot surfaces, steam baths, static electricity, and operation of mechanical and electrical equipment that is not intrinsically safe. Ensure proper grounding and avoid creating static electricity. Be sure to ground metal containers when transferring flammable liquids.	**Eye protection**: Wear ANSI Approved tight-fitting safety goggles or safety glasses with side shields. **Face protection:** Wear a face shield when handling containers of 1,4-dioxane that are not behind a lab hood sash or blast shield. **Gloves**: 1,4 dioxane penetrates most common lab gloves rapidly. Extended contact with 1,4 dioxane is not allowed. To protect against incidental contact, wear Laminate Film gloves (e.g. Ansell Barrier) or double nitrile or butyl gloves (8 mil). Change outer glove as soon as contaminated. **Note**: 1,4 dioxane penetrates 4 mil nitrile gloves nearly instantaneously. **Clothing:** Wear flame resistant lab coat; cotton based clothing/attire; full length pants or equivalent; and close-toed, close-heeled shoes.	Do not allow to evaporate to near dryness unless absence of peroxides has been shown. If 1,4-dioxane is concentrated on the rotary evaporator, use two dry ice traps to collect the solvent vapors. Distillation/evaporation of dioxane efficiently removes all stabilizers. Collected fractions (rotavap) must be treated as unstabilized 1,4-dioxane and must be disposed of soon after generation. Pressure can be built up if 1,4-dioxane is used in reactions. Adequate ventilation (pressure bubbler on Schlenk manifold, or an equilibrating balloon) has to be used to prevent dangerous over pressurization. Pressure is built up if 1,4-dioxane is

		Use a blast shield if 1,4-dioxane may be distilled to dryness or evaporated to dryness. Only when absolutely necessary to transfer larger quantities of 1,4-dioxane, use an appropriately-designed, engineered system that is tested and properly used. Before removing 1,4-dioxane from a glove box, review the proper steps necessary to protect the material from air, or quench excess material before exposing it to air.		used in extractions. Adequate ventilation (open the valve frequently during the extraction) has to be used to prevent dangerous over pressurization. If heated, the reaction apparatus has to be fitted with an adequately sized condenser and an adequate flow of cooling water has to be provided to prevent evaporation. Cooling hoses have to be secured with metal hose clamps to the condenser and the outlet. If distillation or evaporation of 1,4-dioxane to dryness is possible, a second worker should be present outside the potential explosion zone.
Notes	Any deviation from this SOP requires approval from PI.			

Procedure/Use	**Scale**	**Engineering Controls/Equipment**	**PPE (eye, face, gloves, clothing)**	**Procedure Steps and Precautions**
2. 1,4-Dioxane is used in the lab as a solvent in column chromatography.	Up to *4 liters* total eluent volume of 1,4-dioxane	Work with 1,4-dioxane under an inert atmosphere (e.g. argon or nitrogen) in a glove box, vacuum manifold or ventilated fume hood.	**Eye protection**: Wear ANSI Approved tight-fitting safety goggles or safety glasses with side shields. **Face protection:** Wear a face shield when handling containers	Eluent may contain no stabilizers. Use a blast shield if eluent may be evaporated to dryness. Do not allow to evaporate to near dryness unless absence of peroxides

		Eliminate ignition sources such as open flames, hot surfaces, steam baths, static electricity, and operation of mechanical and electrical equipment that is not intrinsically safe. Ensure proper grounding and avoid creating static electricity. Be sure to ground metal containers when transferring flammable liquids. Use a blast shield if 1,4-dioxane may be distilled to dryness or evaporated to dryness. Only when absolutely necessary to transfer larger quantities of 1,4-dioxane, use an appropriately-designed, engineered system that is tested and properly used. Before removing 1,4-dioxane from a glove box, review the proper steps necessary to protect the material from air, or quench excess material before exposing it to air.	of 1,4-dioxane that are not behind a lab hood sash or blast shield. **Gloves**: Wear butyl rubber or Viton gloves. **Clothing:** Wear flame resistant lab coat; cotton based clothing/attire; full length pants or equivalent; and close-toed, close-heeled shoes.	has been shown. If 1,4-dioxane is concentrated on the rotary evaporator use two dry ice traps to collect the solvent vapors. Distillation/evaporation of 1,4-dioxane efficiently removes all stabilizers. Collected fractions (rotavap) must be treated as unstabilized 1,4-dioxane and must be disposed of soon after generation. If distillation or evaporation of 1,4-dioxane to dryness is possible, a second worker should be present outside the potential explosion zone.
Notes	**Any deviation from this SOP requires approval from PI.**			

Sarpong Group Notes for 1,4-dioxane

1,4-Dioxane is a select carcinogen and a peroxide forming chemical (PFC). Like some other ethers, dioxane combines with atmospheric oxygen on standing to form explosive peroxides. Distillation of dioxane concentrates these peroxides, thus increasing the danger. If not stored and handled properly, this can pose a serious threat to the health and safety of laboratory personnel, emergency responders and chemical waste handlers. Hence, it is important to follow safety protocols to handle this chemical.

1,4-Dioxane (dioxane), a cyclic ether, is used as a degreasing agent, as a component of paint and varnish removers, and as a wetting and dispersion agent in the textile industry. Dioxane is used as a solvent in chemical synthesis, as a fluid for scintillation counting, and as a dehydrating agent in the preparation of tissue sections for histology.

Protocol/Procedure

When used as a solvent for chemical reactions, 1,4-dioxane should be handled by lab members wearing a flame-resistant lab coat, gloves, and chemical safety goggles and used only inside a functioning fume hood. Dioxane is used in quantities ranging from <1mL up to 2L, and at temperatures up to 120 ºC. If being used at a temperature higher than its boiling point (101 ºC), the reaction vessel must be capable of handling the pressure buildup and the use of a blast shield is recommended for all volumes, and required if >50mL dioxane is used. After completion of the reaction, any remaining dioxane should be disposed as hazardous waste. If dioxane is to be evaporated using a rotavap, then a dry ice condenser must be employed to trap any volatiles and these disposed of as hazardous waste.

Dioxane is also purified by distillation and is kept on a still in the lab. Efforts should be made to prevent the dioxane from coming into contact with air to limit the danger of developing peroxides. Additionally, the distilled dioxane should be refreshed every couple of days to prevent any buildup of peroxides. Distilled dioxane can also stored in an airtight Schlenk tube. All dioxane, whether distilled or not, should be peroxide tested every 6 months and disposed of through EH&S if peroxides are detected. As a peroxide forming chemical, all containers should be dated with the date they are received and opened. If any old containers of dioxane test positive for the presence of peroxides or are suspected of containing peroxides (due to the presence of white crystals, etc.) they should be tagged as hazardous waste and disposed of properly. Containers should never be shaken if peroxides are suspected, and care should be taken in trying to open old containers of dioxane.

13 - Documentation of Training (signature of all users is required)

- ✓ Prior to conducting any work with 1,4-dioxane, designated personnel must provide training to his/her laboratory personnel specific to the hazards involved in working with this substance, work area decontamination, and emergency procedures.
- ✓ The Principal Investigator must provide his/her laboratory personnel with a copy of this SOP and a copy of the SDS provided by the manufacturer.

I have read and understand the content of this SOP:

Name	Signature	Identifier	Date