Standard Operating Procedures

Strong Oxidizing Agents (SOA), Strong Corrosives – Strong Acids (SA), Acutely Toxic Chemicals (ATC)

Bromine

Print a copy and insert into your laboratory SOP binder.

<table>
<thead>
<tr>
<th>Department:</th>
<th>Chemistry</th>
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<tbody>
<tr>
<td>Date SOP was written:</td>
<td>June 21, 2013</td>
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<tr>
<td>Date SOP was approved by PI/lab supervisor:</td>
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<tr>
<td>Principal Investigator:</td>
<td>Name: Richmond Sarpong</td>
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<td>Signature:</td>
<td>____________________________</td>
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<tr>
<td>Internal Lab Safety Coordinator or Lab Manager:</td>
<td>Name: Rebecca Murphy</td>
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<td>Lab Phone: 510-643-2485</td>
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<td>Emergency Contact:</td>
<td>Name: Richmond Sarpong</td>
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<tr>
<td>Phone Number: 626-644-2407</td>
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<tr>
<td>Location(s) covered by this SOP:</td>
<td>Latimer Hall: 834, 836, 837, 838, 839, 842, 847, 849, 907</td>
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1 - Purpose

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

<table>
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<tr>
<th>Chemical</th>
<th>Use</th>
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| Bromine | 1. Bromine is used in the lab as a reagent in chemical reactions.  
2. Preparation of dilution solutions of bromine.  
3. Quenching solutions of bromine. |

2 - Physical & Chemical Properties/Definition of Chemical Group

CAS#: 7726-95-6
Molecular Formula: Br₂
Form: liquid
Color: brown
Melting point/freezing point: 7.2 °C (45.0 °F) - lit.
Boiling point: 58.8 °C (137.8 °F) - lit.
Vapor pressure: 233 hPa (175 mmHg) at 20 °C (68 °F)
Density: 3.119 g/mL at 25 °C (77 °F)
Flash point: no data available
Lower explosion limit: no data available
Upper explosion limit: no data available
Odor: no data available
Odor Threshold: no data available

3 - Potential Hazards/Toxicity

GHS Classification
Acute toxicity, Oral (Category 5)
Acute toxicity, Inhalation (Category 1)
Skin corrosion (Category 1A)
Serious eye damage (Category 1)
Acute aquatic toxicity (Category 1)

GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)
H303 May be harmful if swallowed.
H314 Causes severe skin burns and eye damage.
H330 Fatal if inhaled.
H400 Very toxic to aquatic life.

Precautionary statement(s)
P260 Do not breathe dust/ fume/ gas/ mist/ vapors/ spray.
P273 Avoid release to the environment.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
P284 Wear respiratory protection.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310 Immediately call a POISON CENTER or doctor/ physician.

Cal/OSHA Permissible Exposure Limits (PEL): 0.1 ppm (0.7 mg/m³) – 8 hour TWA (Ceiling)

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://cehs.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:

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 shelf 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://ccejhs.berkeley.edu/sectionS#Chemical_Handling_Storage_and_Transportation](http://ccejhs.berkeley.edu/sectionS#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:
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 – Bromine

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<thead>
<tr>
<th>Precaution</th>
<th>Description</th>
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| **Preparation**                   | Eliminate incompatible materials from potential spill area.  
Know the location of the nearest fire extinguisher, eyewash, and safety shower before beginning work.  
Never work alone with bromine. Make sure there is another worker present who is also trained in the Bromine SOP.  
Handle bromine only with equipment made of Kynar, Teflon, Monel, Pyrex, glass, or lead-lined steel.  
Bromine is an oxidizing agent and a source of electrophilic bromine used in organic chemistry. It may be used in quantities ranging from <1mL up to 10 mL. Researchers should wear a flame-resistant lab coat, gloves, and safety glasses when handling bromine. All work with bromine should be carried out in a functioning fume hood. Care should be taken when handling bromine to avoid contact with reducing agents to prevent a potentially violent reaction. Contact with certain flammables or combustibles may result in a fire. Vapors are corrosive and hazardous to breathe, so care should be taken so that all vapors remain inside a fume hood and are not released into the lab. After reactions are complete, it is recommended that any excess bromine is quenched with a mild reducing solution, such a sodium thiosulfate before workup. Bromine should be stored in the dark, and away from reducing agents. |
| **Chemical Storage and Disposal** | Keep away from heat, sparks, and flame. Do not store in direct sunlight.  
Store in a tightly closed container. Do not store in polyethylene containers.  
Keep from contact with oxidizing materials. Do not store near combustible materials. Keep away from reducing agents.  
Store in a cool, dry, well-ventilated area away from incompatible substances. Store in a corrosives area.  
Store and transport bromine containers in secondary containment.  
Loosen closure cautiously before opening.  
Collect all bromine liquid waste in labeled 1 gal. plastic containers.  
Store hazardous waste in closed containers, in secondary containment and in a designated location  
Double-bag dry waste contaminated with bromine using transparent bags  
Call EH&S with questions. |
| **Lab-specific Information**      | All work with bromine should be carried out in a functioning fume hood.  
Handle bromine only with equipment made of Kynar, Teflon, Monel, Pyrex, glass, or lead-lined steel  
Avoid reducing agents, alkali metals, powdered metals, aluminum, stainless steel, iron, copper, organic materials, aldehydes, ketones, arsenic powder, amines, amides, phenols, alcohol, ammonia, azides, and ozone. Bromine will attack some types of plastics, rubber, and coatings.  
After reactions are complete, it is recommended that any excess bromine is quenched with a mild reducing agent solution, such a sodium thiosulfate before workup. |
<table>
<thead>
<tr>
<th>Procedure/Use</th>
<th>Scale</th>
<th>Engineering Controls/Equipment</th>
<th>PPE (eye, face, gloves, clothing)</th>
<th>Procedure Steps and Precautions</th>
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| 1. Bromine is used in the lab as a reagent in chemical reactions. | Up to 100 ml bromine per reaction. | All work using bromine must be performed in a ventilated fume hood. | **Eye protection:** Wear tight-fitting safety goggles or safety glasses with side shields.  
**Face protection:** Wear a face shield when handling containers of bromine that are not behind a lab hood sash or blast shield.  
**Gloves:** Use latex or nitrile gloves when working with bromine water. Work with liquid bromine requires fluorinated rubber gloves.  
**Clothing:** Wear fire/flame resistant lab coat (100% cotton based); cotton based clothing/attire; full length pants or equivalent; and close-toed, close-heeled shoes. | Br₂ is a reddish-brown fuming liquid that is very toxic and corrosive. Do not perform reaction outside the fume hood.  
When bromine is in use, have plenty of sodium thiosulfate solution available to deal with spills.  
For reactions performed on small quantities, prepare a solution of Br₂ before adding to your reaction.  
For large scale, Br₂ can be added directly to the reaction mixture.  
If an excess of bromine is used for the reaction, the excess can be quenched with sodium sulfite.  
Bromine is very hazardous upon skin contact. Special Remarks on Explosion Hazards:  
REACTS EXPLOSIVELY WITH ACETYLENE, ACRYLONITRILE, AMMONIA, AZIDES, DIMETHYL FORMAMIDE, ETHYL PHOSPHINE, HYDROGEN, ISOBUTYROPHENONE, NICKEL CARBONYL, NITROGEN TRIIODIDE, OZONE, OXYGEN, DIFLUORIDE, PHOSPHORUS, POTASSIUM, SILVER AZIDE, SODIUM, & SODIUM CARBIDE. |
Reacts with reducing agents, powdered metals, alcohols, aldehydes, amides, amines, aluminum, arsenic powder, copper, iron, ketones, organic materials, phenols, stainless steel. Bromine will attack some types of plastics, rubber, and coatings. Use in a fume hood and cap container when not in use. Dispose of bromine-contaminated gloves and glassware in the appropriate waste container.

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<th>Procedure Steps and Special Precautions for this Procedure</th>
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</table>
| 2. Preparation of dilution solutions of bromine         | Typically used on small scales (<1 g/use) and at high dilutions (0.5% v/v in methanol usually). | All Br₂ should be used inside the confines of a fume hood with a face velocity >100 cfs. When possible, Br₂ should be used cold to minimize Br₂ vapor exposure as bromine is a mucosal irritant. | **Eye protection**: safety glasses with side shields or tightly fitting safety goggles. Face shields are recommended, especially for transfer of bulk chemicals.  
**Hand Protection: Immersion**  
Material: Fluorinated rubber; Minimum layer thickness: 0.7 mm; Break through time: > 480 min.  
**Splash protection**:  
Material: Fluorinated rubber; Minimum layer thickness: 0.7 mm; Break through time: > 30 | Care should be taken when diluting Br₂ as the heat of dilution can often be quite high.  
Always add Br₂ to the solvent, and not vice versa.  
When diluting bromine, always add slowly to minimize local heating especially when adding significant volumes (>10 mL). |
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</table>
| 3. Quenching solutions of bromine | Typically used on small scales (<1 g/use) and at high dilutions (0.5% v/v in methanol usually). | All Br₂ should be used inside the confines of a fume hood with a face velocity >100 cfs. When possible, Br₂ should be used cold to minimize Br₂ vapor exposure as bromine is a mucosal irritant. | **Eye protection:** safety glasses with side shields or tightly fitting safety goggles. Face shields are recommended  
**Hand Protection:** Immersion  
Material: Fluorinated rubber;  
Minimum layer thickness: 0.7 mm; Break through time: > 480 min.  
**Splash protection:**  
Material: Fluorinated rubber;  
Minimum layer thickness: 0.7 mm; Break through time: > 30 min  
**Face Protection:** Wear a face shield for transport of large quantities of bromine. | When using as an oxidant for organic reactions, crude reactions solutions may be quenched during work up with a sodium thiosulfate (10% in water w/v) or a saturated sodium bicarbonate wash. |

**Notes:** Any deviation from this SOP requires approval from PI.
| Body Protection: Wear (fire/flame resistant) lab coat (100% cotton based); cotton based clothing; full length pants or equivalent; and close-toed and close-heeled shoes. |

| Notes | Any deviation from this SOP requires approval from PI. |
Sarpong Group Notes for Bromine

Bromine is a strong oxidizing agent, corrosive, and is also toxic. It is used in organic chemistry as a general oxidant and as an electrophilic source of bromine (“Br”). It is reactive with a wide range of functional groups, especially olefins.

Potential Hazards/Toxicity
Bromine is a strong oxidizer. Contact with other material may cause a fire. This chemical is corrosive and toxic. Causes eye and skin burns. Exposure may cause severe respiratory tract irritation with possible burns. May cause severe digestive tract irritation with possible burns. Lachrymator (substance which increases the flow of tears). May cause central nervous system effects. May cause cardiac disturbances. May cause liver and kidney damage.

Engineering Controls
Work with liquid bromine should be conducted in a fume hood unless other controls are designated in the Protocol/Procedure section. Sash height should be kept low to minimize escaping fumes and provide a physical barrier. A face shield should also be worn when handling liquid bromine.

Eye Protection
Wear chemical splash goggles and a face shield when working with liquid bromine to protect from splash hazards and bromine vapors. This work must take place in a chemical fume hood. The sash should be as low as possible and still allow safe work.

Handling: Wash thoroughly after handling. Use only in a well-ventilated area. Do not breathe dust, vapor, mist, or gas. Do not get in eyes, on skin, or on clothing. Keep container tightly closed. Avoid contact with clothing and other combustible materials. Avoid ingestion and inhalation. Discard contaminated shoes.

Storage: Keep away from heat, sparks, and flame. Do not store near combustible materials. Do not store in direct sunlight. Store in a tightly closed container. Keep from contact with oxidizing materials. Store in a cool, dry, well-ventilated area away from incompatible substances. Store bromine in a corrosives area. Keep away from reducing agents. Loosen closure cautiously before opening.
13 - Documentation of Training (signature of all users is required)

✓ Prior to conducting any work with bromine, 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:

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