**Pyrophoric Materials**

**STANDARD OPERATING PROCEDURE (SOP)**

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

**All personnel subject to these SOP requirements must review a completed SOP and sign the associated training record. Completed SOPs must be kept in the laboratory’s safety binder or be otherwise readily accessible to laboratory personnel. Electronic access is acceptable. SOPs must be reviewed, and revised where needed, as described in the** [**SJSU Chemical Hygiene Plan**](https://www.sjsu.edu/fdo/departments/ehs/lab/Chemical_Hygiene_Plan.pdf)**. Note that not all hazardous chemicals are appropriately addressed in a single Hazard Class SOP, and some chemicals are subject to several Hazard Class SOPs.**

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| Date SOP Written: | |  | |  | Approval Date: | | |  |
| SOP Prepared by: | | **REQUIRED - Insert Preparer's Name** | | | | | | |
| SOP Reviewed and Approved by (name/signature): | | | | **REQUIRED - Insert Approver's Name & Signature** | | | | |
| Department: | | **REQUIRED - Insert Department** | | | |
| Principal Investigator/ Laboratory Supervisor: | | **REQUIRED - Insert Name** | | | | Phone: | **REQUIRED - Insert Phone#** | | |
| Emergency Contact(s): | | **REQUIRED - Insert Name** | | | | Phone: | **REQUIRED - Insert Phone#** | | |
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| Location(s) covered by SOP: | Building: | | **REQUIRED - Insert Name** | | | Lab Phone: | **REQUIRED - Insert Phone#** | | |
| Room #(s): | | **REQUIRED - Insert Number** | | |

1. **HAZARD OVERVIEW**

Pyrophoric materials are substances that can ignite spontaneously upon exposure to oxygen or air. They can also be water-reactive, where heat and a flammable gas are produced. For Pyrophoric materials, oxidation of the compound by oxygen or moisture in air proceeds so rapidly that ignition occurs.

1. **HAZARDOUS CHEMICAL(S)/CLASS OF HAZARDOUS CHEMICAL(S)**

Typical Pyrophorics include, but are not limited to:

1. Metal hydrides (e.g. sodium hydride, diisobutylaluminum hydride, yttrium trihydride);
2. Some finely divided metal powders depending on particle size (e.g. Raney nickel, aluminum powder, zinc powder);
3. White phosphorus and some phosphine compounds (e.g. diphenylphosphine, trimethylphosphine);
4. Alloys of reactive materials (e.g. neodymium-iron-boron alloy)
5. Some organoborane and silane compounds (e.g. bromodimethylborane, trichlorosilane)
6. Some Grignard reagents (e.g. octylmagnesium bromide, allyl magnesium bromide); and
7. Some organometallic compounds, including alkyllithium and alkylzinc reagents (e.g. butyllithium, dimethylzinc).

Materials that spontaneously auto-ignite can be identified using the Safety Data Sheet by the Globally Harmonized System (GHS) using the Hazard Code H250 (Catches fire spontaneously if exposed to air).

**REQUIRED:** List (or attach) the applicable chemical(s) for your laboratory, and describe important properties and signs/symptoms of exposure. The chemical’s Safety Data Sheet (SDS) and [PubChem](https://pubchem.ncbi.nlm.nih.gov/)’s Laboratory Chemical Safety Sheet (LCSS) are excellent sources for this information.

1. **ENGINEERING/VENTILATION CONTROLS**

**The following is a general plan for all Pyrophorics:**

* Work under an inert and dry atmosphere (argon, nitrogen) in an enclosed glove box; or
* Work inside a properly functioning certified chemical fume hood using air-free (e.g., Schlenk) technique when handling Pyrophoric materials. Work with the sash as low as possible.

**Always:**

* Work away from water sources or potential water splash;
* Remove adjacent ignition sources and unneeded flammable/combustible materials;
* Use fresh, dry solvents; and
* If materials or side products are prone to rapid decomposition, use a portable blast shield.

**REQUIRED:** Describe the lab-specific engineering or ventilation controls and equipment safety features (if applicable) that will be used to reduce the risk of Pyrophoric chemical exposure.

1. **ADMINISTRATIVE CONTROLS**

The following elements are required:

1. Complete laboratory safety training prior to working in the laboratory;
2. Complete laboratory-specific safety orientation and training on laboratory-specific safety equipment, procedures, and techniques to be used, including the location of laboratory safety equipment (emergency eyewash, safety shower, fire extinguisher);
3. Demonstrate competency to perform the procedures described in this SOP to the Principal Investigator (PI) or trainer;
4. Be familiar with the location and content of any Safety Data Sheets (SDSs) for the chemicals used (online SDSs are available from [MSDS online](https://msdsmanagement.msdsonline.com/8511b604-100d-449a-9a6b-366eff19da04/ebinder/?nas=True));
5. Inspect all equipment and experimental setups prior to use;
6. Follow best practices for the movement, handling, and storage of hazardous chemicals (see Chapters 5 and 6 of [Prudent Practices in the Laboratory](http://ucanr.edu/sites/ucehs/files/133892.pdf) for more detail). An appropriate spill cleanup kit must be located in the laboratory. Chemical and hazardous waste storage must follow an appropriate segregation scheme and include appropriate labeling. Hazardous chemical waste must be properly labelled, stored in closed containers, in secondary containment, and in a designated location;
7. Do not deviate from the instructions described in this SOP without prior discussion and approval from the PI; and
8. Notify the PI of any accidents, incidents, near-misses, or unexpected outcomes involving the Pyrophorics described in this SOP.

**For Pyrophorics, the following are also required:**

1. Never work alone. All work involving Pyrophorics must be performed in the presence of at least one safety buddy. The safety buddy must be a person who has been trained in the use of Pyrophorics and who is proficient with the Pyrophoric emergency protocols set forth in this SOP. Furthermore, the safety buddy must be within audible and visible range of the person that is handling Pyrophorics at all times, and must not be concurrently working with Pyrophorics or any other compound or process that cannot be easily and safely abandoned;
2. Keep quantities of Pyrophorics used as small as possible, especially when trying new experiments. Increase reaction scale with caution, and only when you have run the reaction on a small scale first. Never use Pyrophorics in a greater scale than has been approved by the PI;
3. Liquids may be safely transferred without a glovebox by employing certain syringe or cannula techniques. While a syringe is appropriate for the transfer of small volumes (less than 10 mL), larger volumes should only be transferred via cannula or in a glovebox. Never transfer more than one aliquot using the same syringe. Never transfer more than half of the volume contained by a syringe (e.g., do not transfer more than 5mL of liquid in a 10 mL syringe). Before transferring, make sure that the material is at the appropriate temperature [see SDS];
4. Ensure all equipment is dry, damage-free, air-free, clean, and appropriate for the task;
5. Be sure to have a quenching scheme for residual materials prior to beginning work;
6. Clear the area of unrelated and incompatible hazards;
7. Clear the area of clutter, especially flammable materials such as organic solvents and paper;
8. Know the location of eye wash/safety shower. Only use Pyrophorics in specific laboratory if the area is properly equipped with this safety equipment located within ten seconds of travel;
9. You **must** have an appropriate extinguishing agent (dry sand, Met-L-X, soda ash, or lime) for the Pyrophoric material you are using immediately available adjacent to your workspace;
10. Pyrophorics should have their own dedicated storage with secondary containment and shall be segregated from incompatibilities. Pyrophoric gases shall be stored in compliance with California Fire Code requirements. Please contact [ehs@sjsu.edu](mailto:ehs@sjsu.edu?subject=Pyrophoric%20material%20storage%20questions) for storage recommendations and requirements; and
11. Minimize your purchases of Pyrophoric materials to quantities that will be used within one year. The date of receipt and date of opening should be written onto the container. Contact [ehs@sjsu.edu](mailto:ehs@sjsu.edu?subject=Pyrophorics%20use/storage%20and%20building%20requirements) for the storage restrictions for your specific laboratory/building.

**REQUIRED:** Insert any laboratory-specific restrictions on maximum quantities of Pyrophorics to be used and stored. Include lab-specific transfer procedure(s), volume threshold for syringe vs. double cannula transfer methods, and any equipment restrictions.

Storage Considerations for Pyrophorics:

* When appropriate, store under inert (e.g. N2, Ar) gas;
* Store all pyrophoric materials in the manufacturer’s container;
* Avoid heat/flames, ignition sources, oxidizers, protonating substances (e.g., acids, alcohols, etc.), and water sources; and
* Storage requirements of the individual materials must be considered (e.g. alkyllithium species should not be stored near strong Lewis acids despite the similar storage requirements for the two species).

**REQUIRED:** Insert descriptions of lab-specific storage, segregation, and any special handling requirements for each chemical or group of chemicals.

1. **PERSONAL PROTECTIVE EQUIPMENT (PPE)**

At a minimum, long pants (covered legs and ankles) and shoes that cover the entire foot are required to enter a laboratory or technical area where hazardous chemicals are used or stored.

In addition to the minimum attire required upon entering a laboratory, the following PPE is required for all work with Pyrophorics:

1. **Eye Protection** (must be ANSI Z87.1-compliant)**:**
   1. At a minimum, safety glasses are necessary.
   2. Splash goggles may be substituted for safety glasses, and are required for processes where splashes are foreseeable or when generating aerosols.
   3. Ordinary prescription glasses are not acceptable eye protection and cannot be used in lieu of proper safety eyewear.
2. **Body Protection:** At a minimum, a flame-resistant (FR) laboratory coat that is NFPA 2112-compliant laboratory coat that fully extends to the wrist is necessary.
   1. Clothing worn under PPE should not be made from synthetic materials;
   2. For chemicals that are corrosive and/or toxic by skin contact/absorption additional protective clothing (e.g. face shield, chemically-resistant apron, disposable sleeves, etc.) are required where splashes or skin contact is foreseeable.
3. **Hand Protection:** Hand protection is needed for the activities described in this SOP. Use of Pyrophorics outside of an inert atmosphere glove box including, but not limited to, movement or handling of reagent bottles, reagent transfer, reagent quenching, and any spill cleanup activities requires:
   1. Gloves that provide sufficient protection from the specific chemicals being used, and ideally do not support a flame (e.g. neoprene is a better option than nitrile, such as Ansell NeoTouch disposable gloves).

**REQUIRED:** Insert lab-specific descriptions of PPE and hygiene practices used with Pyrophorics, including any specialized PPE needed for a procedural step or specific task.

1. **SPILL AND EMERGENCY PROCEDURES**

Do not attempt to clean up a chemical spill unless you have been trained and feel comfortable doing so. Contact the College Safety Team or Environmental Health & Safety (EH&S), for help with cleaning up a small chemical spill. For a large spill of Pyrophoric materials, confine the spill within the fume hood or room, evacuate everyone from the lab, and call 911 (or 408-924-2222 from a non-campus phone).

**Once spilled, liquid or solid Pyrophoric chemicals may ignite.**

The primary emergency response is to extinguish Pyrophoric fires using an appropriate extinguishing agent (dry sand, Met-L-X, soda ash or lime). Primary emergency response to extinguish Pyrophoric fires on a person would be to use an emergency eyewash/safety shower. Additional considerations for a fire involving Pyrophoric materials includes:

1. If possible, immediately isolate the fire from any potential flammable material;
2. If you are not trained/comfortable with the fire extinguishing methods, close the hood completely to keep the fire contained (without additional fuel, small pyrophoric fires will self-extinguish as they are quickly combusted);
3. To extinguish the fire, use an appropriate extinguishing agent for the Pyrophoric material (dry sand, Met-L-X, soda ash or lime);
4. Using a dry chemical Class ABC fire extinguisher may be helpful to manage a collateral fire; and
5. Fire extinguishers containing water (or that may develop water over time), carbon dioxide, or halons are not suitable for fires involving Pyrophoric compounds as they react violently.

**REQUIRED:** Insert description of who to call in case of Pyrophoric spill in the lab.

**REQUIRED:** Describe suitable extinguishing agent to be available in the lab that should be used to extinguish the Pyrophoric chemical spill.

If there is an unusual or unexpected occurrence when using Pyrophorics, the occurrence must be documented and discussed with the Principal Investigator and others who might be using the material(s). Unusual or unexpected occurrences might include a fire, catastrophic failure, sudden rise or drop in temperature, increased rate of gas evolution, color change, phase change, or separation into layers. It is also essential that “Lessons Learned” and “Near Misses” incident reports be maintained and shared within the research group.

1. **WASTE MANAGEMENT AND DECONTAMINATION**

**Waste Management:**

Hazardous waste must be managed as outlined in [SJSU’s Chemical Hygiene Plan](https://www.sjsu.edu/fdo/departments/ehs/lab/Chemical_Hygiene_Plan.pdf), and must be [properly labeled](http://www.science.sjsu.edu/safety/HazWasteForm.pdf). In general, hazardous waste must be removed from your laboratory within 9 months of the accumulation start date.

**Decontamination:**

Carefully inspect work areas to make sure no Pyrophoric materials remain. Clean contaminated work areas with wipers moistened with a dry, non-polar solvent before using polar solvents to clean the area. Be sure all ignition sources are secured before beginning cleaning up with flammable liquids. Be certain that the appropriate quenching procedure is complete before adding materials to a hazardous waste container.

**REQUIRED:** Insert the lab-specific quenching protocol(s) for the Pyrophoric(s) described in this SOP.

**REQUIRED:** Insert description(s) of decontamination procedures for equipment, glassware, and/or controlled areas (e.g. gloveboxes, restricted access hoods, or designated portions of the laboratory).

Upon completion of work with Pyrophorics and/or decontamination of equipment, remove gloves and wash hands with soap and water. Upon leaving the laboratory or designated Pyrophoric work area, remove all PPE worn and wash hands and forearms as needed. Contaminated PPE should not be worn outside of the laboratory. Soiled lab coats should be sent for professional laundering. Grossly contaminated clothing/PPE, and disposable gloves must not be reused and should be disposed of as hazardous waste.

1. **DESIGNATED AREA**

Designated area(s) for the use and storage of Pyrophorics shall be established where limited access, special procedures, knowledge, and work skills are required. Signage indicating the corresponding [Globally Harmonized System (GHS) pictogram(s)](https://www.osha.gov/Publications/HazComm_QuickCard_Pictogram.html) should be visible at the entrance of the designated area (e.g. postings on the exterior of the laboratory door).

**REQUIRED:** Insert description(s) of the designated area(s) for Pyrophorics in your laboratory. The entire laboratory, a portion of the laboratory, a fume hood, etc. can be designated.

1. **DETAILED PROTOCOL**

**REQUIRED:** Insert the lab-specific protocol for the process, hazardous chemical(s), or hazard class described in this SOP. Include any relevant resources such as journal articles, patents, etc. as desired.

**TEMPLATE REVISION HISTORY**

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| --- | --- | --- | --- |
| **Version** | **Date Implemented** | **Author** | **Revision Notes:** |
| **1.0** | **4/3/2020** | **Alexi Ball-Jones** | **New template** |
| **1.1** | **10/27/2020** | **Alexi Ball-Jones** | **Updated hyperlinks** |
| **1.2** | **5/11/2012** | **Alexi Ball-Jones** | **Added** [**ehs@sjsu.edu**](mailto:ehs@sjsu.edu) **link** |
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**LAB-SPECIFIC REVISION HISTORY**

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| --- | --- | --- | --- |
| **Version** | **Date Approved** | **Author** | **Revision Notes:** |
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**Documentation of Standard Operating Procedure Training**

*(Signature of all users is required)*

* Prior to use of **Pyrophorics**, laboratory personnel must be trained on the hazards involved in working with this SOP, how to protect themselves from the hazards, and emergency procedures.
* Ready access to this SOP and to a Safety Data Sheet for each hazardous material described in the SOP must be made available.
* The Principal Investigator (PI), or the Laboratory Supervisor if the activity does not involve a PI, must ensure that their laboratory personnel have attended appropriate laboratory safety training or refresher training within the last three years.
* Training must be repeated following any revision to the content of this SOP.

**Designated Trainer:** *(signature is required)*

I have read and acknowledge the contents, requirements, and responsibilities outlined in this SOP:

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| **Name** | **Signature** | **Trainer Initials** | **Date** |
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