



## Safety and Risk Management

### Pyrophoric Chemicals: Safe Work Practices Information Page

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**I. Background.** Pyrophorics are extremely reactive liquids and solids that will ignite spontaneously in air at a temperature of 130° F (54.4° C) or below. They are extremely reactive toward oxygen and in most cases, water. Pyrophoric chemicals can be handled and stored safely as long as exposure to atmospheric oxygen and moisture is avoided. Solids must be transferred under an inert atmosphere or otherwise protected. Failure to follow proper handling techniques could result in serious injury, death, and/or property damage. The following types of compounds often include pyrophorics: finely divided metals, alkali metals, metal and non-metal hydrides, Grignard reagents, and metal carbonyls, among others. Common examples of pyrophorics are butyllithium, tributylaluminum, white phosphorus, magnesium amide, and titanium dichloride.

**II. Purpose.** The purpose of this paper is to provide principle investigators (PI) and their staff with information regarding health hazards, safe work methods, and provisions for suitable personal protective equipment (PPE) that effectively reduces the risk of occupational exposure or injury from pyrophoric materials.

#### **III. Occupational Exposure Hazards.**

A. In accordance with the VCU Safety Manual, PIs are responsible for ensuring a safe work environment within their individual laboratories. Training of all laboratory personnel, including general safety training, as well as job specific training, is an important part of maintaining a safe working environment. Any employees working with pyrophoric chemicals must be made aware of the hazards associated with these materials. Pyrophoric chemicals present certain safety hazards that must be addressed before handling or using them, both in terms of facilities and PPE. The most marked hazard associated with pyrophoric materials is spontaneous flammability. Pyrophorics are associated with fire and explosion hazards and care must be taken to avoid conditions which could allow such reactions to occur. All combustible material, including paper products, must not be allowed to come in contact with pyrophoric materials. Store pyrophorics away from sources of ignition and minimize the quantities of pyrophoric chemicals stored in the laboratory. Never return excess chemicals to the original container. Small amounts of impurities may be introduced into the container which may cause a fire or explosion. For pyrophoric compounds, a Class D fire extinguisher must be kept nearby and knowing the location of the nearest safety shower and how to use it is imperative. If individuals are expected to use fire extinguishers, they must have been trained within the past twelve months.



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**B. Recent Incidents.** Recent catastrophic laboratory accidents involving pyrophoric chemicals have underscored the hazardous nature of these compounds. A laboratory employee at a major university was working in a biochemistry laboratory when she extracted t-butyllithium from a reagent bottle using a syringe. While the exact sequence is not known, speculation is that while withdrawing the chemical from the original container, she pulled the plunger out of the back of the syringe barrel causing the chemical to splash across her chest. Once exposed to air, this chemical spontaneously ignited causing burns which were eventually fatal. The employee was not wearing appropriate PPE at the time of the accident. While there is no guarantee that use of prescribed PPE would have prevented the ultimate outcome, perhaps appropriate PPE could have ameliorated the consequences of this accident. Additional information regarding this tragic accident can be found here: <https://www.chemistryworld.com/news/ucla-lab-assistant-dies/3004085.article>

**IV. Safe Work Methods.** Due to the potential pyrophoric chemical-related occupational exposure hazards discussed above, PIs must conduct a thorough risk assessment of their procedures and prepare protocols and standard operating procedures (SOP) addressing how to safely work with such materials. The safe work methods listed below provide general guidance on how to work safely with pyrophoric chemicals. However, PIs whose laboratory chemical inventory includes pyrophoric chemicals should prepare specific written procedures for working with such materials and should ensure that all laboratory staff is appropriately trained on proper procedures before being allowed to work with pyrophorics. Principal investigators should satisfy themselves that workers and students within their laboratories are competent to safely handle spontaneously reactive materials.

### **A. Administrative controls.**

1. Management considerations for pyrophorics and other potentially hazardous chemicals must be included in the laboratory [Chemical Hygiene Plan](#).
2. Principal investigators will develop and implement SOP(s) for work practices and procedures involving pyrophorics and other highly reactive chemicals.
3. All tasks having potential for occupational pyrophoric exposure will only be conducted by competent staff who have received appropriate training (OSHA: “Worker Right to Know” as well as task-specific training) regarding the specific pyrophoric-related health and safety risks, SOPs, and procedures to be followed in event of an exposure incident.
4. Whenever possible, PIs should consider the use of (less hazardous) alternative chemicals that are not pyrophoric. If less reactive materials cannot be substituted, consider conducting the experiment as a pilot to confirm that appropriate safeguards are present and operable.



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### **B. Engineering Controls.**

1. Eyewash. Where the potential exists for eye exposure, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use. Laboratory staff should be trained on eyewash location and operation. The eyewash should be tested and documented weekly by laboratory staff and inspected by VCU's Occupational Safety Section on an annual basis (the annual inspection should be documented on a toe-tag attached to the eyewash). Bottle-type eyewash stations are not acceptable.

2. Safety shower. In areas where pyrophoric chemicals are used, a safety shower must be within the immediate work area. Laboratory staff should be trained on emergency shower location and operation. The shower should be inspected by VCU's Occupational Safety Section on an annual basis.

#### 3. Storage.

a. Consideration for appropriate storage of pyrophoric and other highly-reactive materials should be made prior to introducing the material into the laboratory. Only those quantities of material needed should be brought into the laboratory to minimize storage and disposal requirements.

b. Fume hood. Some pyrophoric chemicals release flammable gases and should be handled only in a chemical fume hood. Refer to the safety data sheet (SDS) for appropriate handling instructions. In addition, some pyrophoric materials must be stored under a flammable solvent (such as kerosene) and the use of a fume hood is required to prevent the release of flammable and/or flammable vapors into the laboratory.

c. All containers of pyrophoric or other highly reactive material must be labeled with the date of receipt. The container should also have a highly visible label indicating hazardous situations to avoid (e.g., do not expose to air, etc.). Upon expiration, containers of pyrophoric or other highly reactive chemicals should be promptly disposed of through the university hazardous waste disposal program. Containers delivered to OEHS hazardous waste management personnel must be conspicuously marked.

4. Glove box. If an inert atmosphere is required to work with the pyrophoric material, a glove box may be used. All laboratory staff working with a glove box must first be appropriately trained and determined to be competent by the PI. The glove box must be inspected/certified regularly or as recommended by the manufacturer.



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### **C. Personal Protective Equipment (PPE).**

1. Laboratory coats. A long-sleeved fire-resistant laboratory coat which is properly buttoned or closed should be worn at all times when working with pyrophoric chemicals. In addition, it is recommended to wear fire-resistant clothing, such as cotton or wool, as opposed to synthetic clothing not intended to be fire resistant while working with pyrophorics. Certain fire resistant synthetic fabrics such as Nomex<sup>®</sup> may be appropriate when engineering controls cannot completely eliminate the hazard. Shorts and open-toed shoes are inappropriate laboratory attire for working with pyrophorics and/or any other hazardous chemicals.

2. Eye Protection. Eye protection must be worn at all times while working with pyrophoric materials. Safety glasses must meet ANSI Z87.1-2003 standard requirements and should be equipped with side shields. However, regular safety glasses do not provide adequate protection against splashes; therefore, whenever the potential for a splash-hazard exists, additional eye protection and/or face protection must be worn (e.g., safety goggles and face shield). Ordinary prescription eyeglasses do NOT provide adequate protection.

3. Gloves. Wear appropriate gloves when working with hazardous chemicals, including pyrophoric and other highly reactive chemicals. Fire resistant gloves (such as Nomex<sup>®</sup>) are recommended. While nitrile gloves provide adequate protection against accidental skin/hand contact with small quantities of most laboratory chemicals, one should consult the SDS for specific recommendations on PPE, including appropriate gloves. Resistance of glove materials varies with the chemical involved. If in doubt as to the appropriateness of a glove material for the chemical you are using, contact the Chemical and Biological Safety Section (CBSS) for assistance.

### **D. Work Methods.**

1. Perform a thorough and comprehensive hazard assessment of the experiment. The hazard assessment should address such issues as proper use and handling techniques, chemical toxicity, storage requirements, fire safety, spill response, and emergency procedures to follow in the event of personnel exposure, spill, fire, or other reasonably anticipated accident.

2. Clearly label all pyrophoric chemical containers in plain English with the correct chemical name, hazard warning, and a received and/or opened date. Appropriately label any secondary containers as required by the chemical hygiene plan. Avoid writing directly on the bottle with a grease pen or sharpie, as such labels often get washed off or may react with vapors from the contents. Materials with an expiration date should be disposed of through the university hazardous waste disposal program promptly following expiration.



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3. Special storage considerations for pyrophoric chemicals should be determined before the material is introduced into the laboratory and appropriate storage means must be available. The chemical SDS should be reviewed and consulted regarding storage requirements. Pyrophoric chemicals should be stored under an atmosphere of inert gas or other inerting material as dictated by the pyrophoric material. Pyrophoric chemicals should not be stored with oxidizers or near water. Keep away from sources of ignition, heat, and/or flames. In an effort to minimize storage of pyrophoric chemicals, only working quantities of pyrophoric chemicals should be kept in the laboratory. Excess chemicals should never be returned to the original container, as small amounts of impurities may be introduced into the container, which could cause a fire or explosion. All laboratory staff should be appropriately trained on such requirements.

**E. Spills.** Laboratories employees and students working with pyrophoric chemicals must have a spill kit appropriate for the pyrophoric compounds in use in the laboratory. The spill response materials should be inert and non-reactive. If a spill occurs, alert other personnel in the laboratory. Turn off all sources of ignition (if safe to do so). Do not attempt to handle a large spill in which you are not trained and/or equipped to handle. Vacate the laboratory immediately and call CBSS at 828-1392. If a spill occurs after work hours, call 828-9834 and ask to have the Chemical Safety individual on-call paged. Remain on the scene, but at a safe distance, to receive and provide information to safety personnel when they arrive.

**F. Waste Disposal.** All hazardous waste should be disposed of through the university hazardous waste disposal program. Removal of potentially pyrophoric material from a glove box may involve first placing the material in a quenching material. The PI must ensure that these procedures are clearly communicated by training laboratory personnel and ensuring that the supplies necessary are available prior to beginning work with pyrophoric chemicals. All materials contaminated with pyrophoric materials pose a flammability risk and must be properly containerized and disposed of as hazardous waste. Contaminated materials should not be left in the laboratory overnight. To set-up a hazardous waste appointment, please call CBSS at 828-1392. If you request disposal of contaminated equipment, expired chemicals, or other situations involving pyrophoric or highly reactive materials determined by CBSS to present an unacceptable risk, a qualified hazardous waste contractor will be retained at your laboratory's expense.

**G. Emergency Procedures.** The PI should anticipate possible emergencies in the laboratory involving pyrophoric chemicals, such as fires, explosions, spills, and/or injury to staff. All laboratory personnel should be trained on emergency procedures for an incident involving pyrophoric materials. At a minimum, these procedures should address the following:

1. Whom to contact. Numbers (both daytime and evening) should be provided for those who may need to respond, including the PI, VCU OEHS (828-9834), Student Health/Employee Health, and VCU Police.



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2. Location of safety equipment including the eyewash, safety shower, fire alarm, and spill kit.

3. How to alert personnel in potentially hazardous areas.

4. First aid and/or procedures to assist injured laboratory personnel until medical help arrives on the scene.

### References.

SOP for Pyrophoric Chemicals. University of Rochester Environmental Health and Safety. Available at: <http://www.safety.rochester.edu/ih/standops8.html>

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