Stanford | Environmental Health & Safety
Research Safety

n-Butyllithium: Lessons Learned

Purpose

This Lessons Learned focuses on an incident involving flammable material, and how advanced preparation, as well as appropriate and quick response, helped prevent the incident from becoming more serious. It also demonstrates why it is important to make sure equipment is compatible with the items you will use in your experiments.

What Happened?

A researcher was performing an enolate alkylation reaction that they had done previously and was preparing lithium diisopropylamide (LDA), which involved the use of the pyrophoric n-butyllithium (n-BuLi; see inset Background box). They had generally appropriate PPE (flame-resistant lab coat, safety glasses, nitrile gloves, and lab-appropriate attire), had reviewed the lab SOP on pyrophorics, and had notified a nearby labmate (who was also trained on work with pyrophorics) of their intentions. They prepared a quench solution of ethyl acetate in hexanes in advance to deactivate unwanted n-BuLi, made sure their workspace was clear of other combustible material, clamped the bottle of 1.55 M n-BuLi in hexanes to a work stand so it could not tip over, and brought a Class D fire extinguisher to their hood. They noted that the 1 mL syringe they had (BD Disposable Syringes with Luer-Lok™ Tips, Manufacturer: BD 309628) were not the lab's usual brand and model.

Background

- n-Butyllithium is a pyrophoric material, meaning it will ignite upon sustained contact with air.
- Transfer of n-butyllithium at small scales is often accomplished using a syringe.
- Even if you or your lab do not work with this specific material, this Lessons Learned contains good practices for working with any high hazard material.

The researcher used the syringe to withdraw approximately 0.5 mL of n-BuLi from a bottle and pulled the needle into the headspace of the bottle to subsequently draw in argon—a common practice to ensure no air comes in contact with the pyrophoric material. Shortly after, the researcher felt heat on the hand holding the syringe and immediately suspected a pyrophoric reaction was taking placed from leaked n-BuLi. They reacted quickly, doffing their glove properly, grabbing it by the palm and inverting it as it was removed, which likely limited air exposure and thus helped prevent the n-BuLi on it from igniting. They proceeded to rinse their hands at the nearest sink. The researcher also called to their nearby labmate to notify them of the issue and asked them to quench the syringe, which their labmate did successfully before any flames started. The researcher continued rinsing their hand for 15 minutes and called their PI.

Later, the researcher shared their experience in group meeting, and other lab members mentioned that they had experienced issues when using organic solvents with this new brand of syringes, though none had experienced leaks; in most instances, they had issues with the plunger getting stuck. They removed the remaining syringes from use in the lab and procedures were put in place to ensure the specific syringes were

not ordered again. The researcher submitted an SU-17 incident report.

Thanks to the researcher's training and preparedness when working with a hazardous material, and their quick thinking and appropriate reaction to the possibility of a pyrophoric material fire, the researcher was able to return to work that same day and was even able to successfully complete their reaction with guidance from a postdoc.

Why Did This Happen?
The root cause was use of a syringe that was incompatible with the solvent being drawn up, resulting in degradation of the plunger's rubber due to contact with organic solvents, and subsequently an incomplete seal between the plunger and the barrel of the syringe, allowing the solvent to leak out of the syringe. It is important to note that this may not imply any defect in the syringe or fault by the manufacturer; plastic syringes of this type are generally sold for medical use and are not designed with chemical use in mind. When working with solvents or other items that may interact with specific materials, be sure to check your experimental set up to evaluate this potential and use appropriate combinations of materials.

What Went Right?
This incident is a textbook example of the value of multiple layers of safety controls. The researcher did an excellent job preparing (reviewing the SOP, preparing safety equipment, etc.), and the lab as a whole has a culture that encourages researchers to be open with each other and their PI, and to assist each other when needed.

- The researcher was working in a certified chemical fume hood with the hood sash at the proper operating height.
- The researcher had completed all relevant trainings. Of note, they had completed hands-on trainings where they were taught how to properly doff their PPE, as well as on fire extinguisher use. The researcher stated that, thanks to their training, they knew what to do.
- The researcher had reviewed the lab's SOP on working with pyrophorics before their work, which contained many of the good practices noted below. To quote the researcher, "the SOP was a great investment of time."
    - A general use SOP for highly reactive materials can be found on EH&S' website.
- The researcher prepared their workspace properly. All unnecessary materials, particularly combustible materials, had been removed from their fume hood. They had secured the bottle of n-BuLi so it could not be easily spilled. They had a quench solution prepared either in case of accident or to use in the course of the experiment. They had the correct class of fire extinguisher readily available in the event of a fire.
- The researcher used the minimum amount of material necessary to complete their reaction. This meant that even in the scenario described here, a very small amount of hazardous material leaked.
- The researcher was working with pyrophoric material while there was another person present in lab (as opposed to working with it while alone). They notified this person, so when something did go wrong, they were ready to provide assistance. This second person had also completed the relevant trainings and was prepared to help as needed.
- The researcher rinsed their hand for the correct duration, 15 minutes. This ensured that any

hazardous material that may have penetrated the glove would be effectively rinsed away.

- The researcher promptly contacted their PI. The PI has consistently promoted openness regarding lab incidents, emphasizing them as opportunities to learn. This openness led to the realization that the incident was not due to a single incompatible syringe, but was intrinsic to the model of syringe, resulting in removal of these syringes from the lab.
    - Information regarding these syringes was distributed more widely by EH&S. Several labs subsequently reached out sharing that they had the same brand and model of syringes and were glad to have gotten a warning before they experienced an incident.
- The researcher was wearing generally proper PPE. The gloves prevented the hazardous material from contacting their skin directly. While no fire developed, if it had, their flame-resistant lab coat would have given them time to remove it before the fire spread to their body.

What Lessons Are There?

- Do not assume that plastic or rubber materials are compatible with hazardous materials. The exact formulation of plastic/rubber often varies between manufacturer, so even materials that look the same may have different chemical compatibilities. Consult the manufacturer's guidance on compatibility before using new materials.
- Institute within your lab the practices displayed by the researcher and their lab. Proper training, preparation, and action can avert injury, minimize the impact of incidents, and ensure the health and safety of all researchers.
- Encourage researchers to report incidents and near-misses in an open and honest manner to encourage review, dialogue, and analysis of necessary safety changes, in partnership with EH&S. EH&S follow-up focuses on what happened and what can be updated to keep the person, the lab and all researchers safe, not on assigning blame.

If you have any questions, please feel free to contact EH&S by calling (650) 723-0448 or submitting a question on our website.