ABSTRACT: Strong reducing agents like lithium aluminum hydride (LiAlH₄, LAH) are frequently employed by industry and academic laboratories in syntheses and other research applications. Due to LAH’s reactivity, several laboratory explosions and fires have been documented in the literature and on various EH&S webpages at universities. Some of the accidents were caused by incorrect handling of LAH or by improper chemical processes, such as weighing on regular paper, grinding, and creating friction, using contaminated solvents and glassware, and physically scraping the material during transfers. In many of these cases, researchers did not have access to a guidance document or an SOP for many of these incidents, and no thorough risk assessment was carried out. Academic laboratories can avoid similar accidents and associated property damage by developing a safety guidance document that identifies every facet of LAH manipulation in the experiment, including reaction setup, procedures for weighing and transferring material to the reaction vessel, heating, and cooling during the reaction, quenching the reaction, and waste disposal. This LAH guidance document can be used to produce a manipulation-specific SOP that covers best practices and precautions for a variety of substrates and reaction scales.

KEYWORDS: fire, guidance document, hazards, housekeeping, lithium aluminum hydride (LiAlH₄, LAH), reduction, standard operating procedures, syringes, THF, toxic, training

1. INTRODUCTION

Lithium aluminum hydride (LAH) is routinely used in organic synthesis to reduce a variety of functional groups such as acids, epoxides, esters, ketones, lactones, and nitriles (Figure 1). This reagent has broad reactivity, and generally, reductions are easily carried out at ambient or elevated (reflux) temperatures, depending on the nature of the substrates. Ethereal solvents, such as anhydrous diethyl ether or tetrahydrofuran (THF), which are themselves flammable are used as solvents for LAH manipulations. Since LAH reductions are typically exothermic requiring effective cooling of the reaction mixture to prevent substrate degradation and unintended outcomes like runaway reactions. Water and protic solvents should not be used because LAH reacts with them.

LAH is so reactive that several fires have occurred not because of flawed storage, but rather because of its handling during the manipulation. For example, Merlic and co-workers reported a fire started during grinding of LAH. In this report, the cause and prevention of LAH grinding and manipulations are precisely described. During another LAH manipulation, an incorrect ratio of LAH and solvent resulted in excess H₂ gas production in a reaction vessel, causing overpressurization. As a result, the reaction mixture spilled inside the chemical fume hood and triggered a fire. Another LAH manipulation fire occurred when a student was trying to transfer LAH from a container using a metal spatula and normal paper.

Environment, health, and safety divisions of universities typically have several SOPs, or policy documents, published on their Web sites. However, these publications are directed at safety professionals and are less helpful for bench chemists. Furthermore, for LAH reductions, technical and reaction-specific information is typically left out of most SOPs, or safety documents. Several research articles on LAH-mediated reductions lack experimental information, despite the abundance of literature on the subject. Thus, the goal of this guideline for LAH reduction is to provide researchers with...
guidance when developing an SOP for LAH reduction tailored for a range of substrates and scales. When using this guidance document for creating a structured standard operating procedure (Figure 2) for LAH reduction, it is important to include an overview of the technique, instructions for assembling the reaction setup, the general procedure (heating and cooling), identification of physical and chemical hazards, steps for reducing or eliminating risks, emergency response protocols for “what-if” scenarios, and waste management protocols.

SOPs and guidance documents to handle hazardous compounds are widely available online. Nevertheless, since comprehensive instructions for handling LAH in the reactions that need to be performed are not available, we are here to provide a reasonable general guideline document for LAH.

1.1. Hazard Identification. LAH is an air- and moisture-sensitive solid. In contact with water, it releases hydrogen gas that may ignite spontaneously.134,35 It is corrosive to the skin, eyes, and mucous membranes (Figure 3). LAH dust can cause injury if it encounters the skin, eyes, or mucous membranes because it reacts with water to form hydroxides. Furthermore, a significant quantity of LAH is likely to burn severely upon contact with skin.

LiAlH₄ + 4H₂O → 4H₂ + LiOH + Al(OH)₃

Perform a literature search on the reagent and substrate reactivity to complete a risk assessment on the LAH manipulations (Figure 3 and Table 1). For LAH use, there are several subpar or flawed literature procedures. As a result, it is advised that you thoroughly read the published material and this guidance document. Regardless of the results of their literature search, a researcher working with LAH, especially for the first time, should get feedback and assistance from the principal investigator and senior lab members (or even talk with someone from a different lab with experience!). Researchers may be exposed to inherent dangers because structural changes to the substrate and reaction conditions can greatly affect LAH reactivity. As a result, an assessment of the substrate and reaction conditions is essential. It has been determined that compounds containing aluminum and perfluorophenol substituents have the potential to explode.36−45

1.2. Hazard Control. 1.2.1. Substitutions. Academic laboratories use LAH far too often; in industry, this is not usual. When reducing aldehyde or ketone, less reactive hydride reagents such as sodium borohydride (NaBH₄) work just as well and do not require the use of LAH.

1.2.2. Engineering Controls. A fume hood equipped with a vertical sash or a combination sash will serve as an effective engineering control. The chemical fume hood should be free of unwanted items and chemicals, especially flammable solvents. Glove boxes are also an option for manipulating LAH and for small scale and ambient temperature substrate reduction purposes (Figure 4).

1.2.3. Administrative Controls. A novice should not attempt the LAH manipulations on their own, since LAH is quite reactive and has caused numerous fires. When a researcher uses LAH for the first time, a more experienced lab member should supervise and provide guidance. Follow the guideline document, SOP, and literature exactly; do not deviate from this without first consulting the PI. If scales exceed the guidelines’ limitations, an updated risk assessment might be necessary.

1.2.4. PPE. Long pants, closed-toe shoes, nitrile gloves, safety glasses, and a flame-retardant lab coat were worn for protection during LAH manipulations.
Figure 3. THF & LAH: GHS pictograms with hazard statements.

Table 1. Hazard Assessment for LAH-Mediated Reduction (What-if Strategy)\(^6\)

<table>
<thead>
<tr>
<th>department: chemistry/biochemistry</th>
<th>description of operation: use of LAH for organic syntheses</th>
<th>review team date 11/01/2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>using a rxn flask that is too small for the LAH reduction</td>
<td>discharge of the mixture from the flask</td>
<td>high</td>
</tr>
<tr>
<td>the rxn vessel is not moisture free</td>
<td>creation of an explosive atmosphere because of H(_2) formation</td>
<td>high</td>
</tr>
<tr>
<td>the rxn mixture cannot be effectively stirred with the current magnetic bar</td>
<td>inadequate heat transfer and insufficient rxn mass stirring</td>
<td>medium</td>
</tr>
<tr>
<td>the rxn mixture cannot be effectively stirred with the current magnetic bar</td>
<td>pressure build-up</td>
<td>high</td>
</tr>
<tr>
<td>the reactor vessel is not moisture free</td>
<td>creation of an explosive atmosphere because of H(_2) formation</td>
<td>high</td>
</tr>
<tr>
<td>the reactor vessel is not moisture free</td>
<td>solid LAH will blow in air because of uncontrolled temperature</td>
<td>high</td>
</tr>
<tr>
<td>the reactor vessel is not moisture free</td>
<td>potential uncontrolled reaction; potential loss of containment</td>
<td>high</td>
</tr>
<tr>
<td>the reactor vessel is not moisture free</td>
<td>inability to condense ether or THF-based solvents</td>
<td>high</td>
</tr>
<tr>
<td>the reactor vessel is not moisture free</td>
<td>potential for air to enter the reactor</td>
<td>high</td>
</tr>
<tr>
<td>the reactor vessel is not moisture free</td>
<td>failure to condense volatiles such as ether or THF</td>
<td>high</td>
</tr>
<tr>
<td>the reactor vessel is not moisture free</td>
<td>LAH pellets are grinded using a ceramic pestle</td>
<td>high</td>
</tr>
</tbody>
</table>

An experienced laboratory member (a senior student or postdoctoral associate) can guide a novice through each phase of the what-if analysis for the hazard assessment procedure. A thorough LAH manipulation reaction setup diagram and any prepared step-by-step operating instructions may be used by the lab member.\(^6\) The following topics should be considered when posing questions regarding LAH manipulations: possible human mistakes; equipment component failures; and deviations from the expected or scheduled critical parameters (such as temperature, pressure, time, and flow rate). Human error occurs regardless of experience level or education. Human error factors may impact decisions about written SOPs, engineering controls, etc.\(^6\) If the solvent volume is 200 mL, use a 500 mL three-neck round-bottom flask.

Figure 4. Use of an inert atmosphere and glovebox (right) for LAH manipulations.
2. SUITABLE REACTION SETUP FOR LAH REDUCTION

Assemble glassware (Figure 5) inside a properly functioning chemical fume hood or glovebox (for small-scale and ambient temperature reactions).

2.1. For a Small-Scale Reaction (up to 5.0 g of LAH).
You can use a small round-bottom flask (RBF) with three or two necks. Make sure the flask is clamped correctly to prevent the reaction mixture from being spilled (Figure 5). Choose a flask size so that, following a full reaction and the addition of all quenching agents, it is no more than two-thirds full.

The flask should be equipped with an oval-shaped magnetic bar, a stir plate, and an inert gas inlet, and the remaining necks of the flask should be equipped with a condenser and an additional funnel for the addition of substrate and quenching reagent. A Schlenk line nitrogen port or a nitrogen source from a cylinder can be used to generate an inert atmosphere. A cooling bath is typically utilized under the reaction flask during the LAH addition, and it is best practice to support it with a laboratory jack so that it can easily be removed without attempting to move the reaction flask assembly.

2.2. For a Large-Scale Reaction (>5.0 g).
Reaction glassware should consist of a 3-neck RBF equipped with a nitrogen gas line and a reflux condenser (Figure 6). A mechanical stirrer is recommended for large-scale reactions to stir the mixture efficiently. A cooling bath is typically necessary, and due to the limitations of heat transfer, a slow addition of LAH is usually required. The risks posed by a large-scale LAH reaction will not be the same as those of a small-scale reaction.

2.3. Best Practice (Glassware Cleaning and Drying).
The glassware that is utilized in the reaction must be clean and without impurities. Use only glassware that is free of chips, cracks, and nicks. Moisture must be removed from THF and substrates. A large-scale assembly consisting of a large condenser, a 1 L flask, and a dropping funnel cannot be dried in a desiccator. These large-scale reaction assemblies are best dried with a heat gun, a vacuum, and nitrogen. This method works better at removing surface moisture. Stopcocks and glass joints should not be heated over a flame. Small flasks and small condensers, on the other hand, are typically easy to dry in an oven and can be bought at room temperature under a calcium chloride desiccator.

NOTE: Stress may arise if a particular area of glass is exposed to direct or concentrated heat from a heat source, such as a Bunsen burner. Bunsen burner use might cause stuck joints, as well. As a result, for LAH manipulation on large-scale glass assemblies, the use of a heat gun is recommended.

After assembling the setup in a chemical fume hood, connect the reaction assembly to a vacuum source and nitrogen (Figure 7). Nitrogen and a vacuum are appropriate for this drying, where nitrogen is used as an inert gas for flushing out the residual moisture. Carefully heat the assembly using a heat gun and continuously evacuate it, then purge the assembly with nitrogen. Repeat this step 3–4 times to remove all the moisture. The Tygon tubes used for chilled water fitted to the condenser and Keck Clips for connections should not be heated during this process. Keck clips lose their holding capacity if they are heated at high temperatures or used incorrectly.

2.4. Weighing LAH
Weigh out LAH just before using it in the reaction. LAH powder can be measured into scintillation vials, solid addition tubes (Merlic), or glass containers with a lid (Figure 5) inside a glovebox or outside, carefully, and safely transferred inside a chemical fume hood under an inert atmosphere for further manipulation. In practice, especially on a small scale, most people just weigh LAH out in the open. You can keep a small container of LAH in the glovebox for handling and weighing if laboratories handle the chemical frequently. Be aware that there have been numerous reports of fires starting when a metallic spatula is used for LAH transfer. Therefore, the...
use of a plastic or a ceramic spatula for LAH transfer is recommended.\textsuperscript{48} Any minor spills inside the glovebox should be cleaned immediately to avoid contamination. Laboratories without access to a glovebox can also transfer LAH under a nitrogen atmosphere outside or inside a glove bag with care. Finally, be prepared in advance by having proper training on laboratory emergency procedures, such as how to use sand to cover the material or using a class D fire extinguisher if the LAH catches fire.

3. GENERAL USE/PROCEDURE

Generally, two methods are employed to transfer LAH for reduction: (i) normal addition and (ii) inverse addition. During a normal addition, a solution of the substrate is added to a mixture of LAH in THF or diethyl ether under an inert atmosphere.\textsuperscript{49} For the second method, the LAH solution is added to the substrate in a desired solvent. The inverse addition is used when the substrate is selectively reduced to the desired product and to control the reaction exotherm. As an example, cinnamaldehyde is reduced to hydrocinnamyl alcohol when reduced with an excess of LAH (>2.0 equiv) by the normal addition method. In this method, a solution of cinnamaldehyde is added to the solution of LAH. With excess LAH, both the double bond and the carbonyl group are reduced. However, cinnamaldehyde is reduced to cinnamyl alcohol with 1.0 equiv of LAH in the inverse addition method (Figure 8).\textsuperscript{50,51}

- Ensure that the reaction flask is moisture free and is under an inert gas blanket.
- Use of a laboratory jack is recommended (prudent practice) to replace a cooling bath with an oil bath when the reaction is carried at an elevated temperature (Figure 9).
- To prevent moisture from surrounding the reaction setup, it is advised to use an oil bath or sand bath for heating instead of a water bath. Oil baths generally provide homogeneous and controlled heating for LAH manipulations.
- To prevent the formation of a crust above the liquid or sediment at the bottom of a heated flask, gentle and efficient stirring is essential.
- Add enough anhydrous solvent\textsuperscript{52} to the flask so that the LAH is easily stirred to cool the mixture.

Most researchers usually run reactions at 0.1 to 1 M in the key substrate. The issue with LAH reductions is that if they are too concentrated, a gel will form during the reaction or upon quenching. Therefore, the more diluted reaction mixture is better.

- The low ratio of LAH to substrate (1.0 to 2.0) is recommended to avoid workup difficulty and runaway reactions. This is determined based on the nature of the substrate.

During the reduction, only around two of LAH’s four hydrides are typically used; quenching the other three poses a serious risk if only one is utilized (nearly like LAH). However, the last hydride, which is more parallel to sodium borohydride, is not as reactive in quenching when three are employed. Therefore, three hydrides will remain in a 1:1 molar ratio of substrate to LAH if one is reducing an aldehyde, epoxide, or ketone (to the alcohol). As a result, it is safer to use a 2:1 molar ratio of the substrate to LAH rather than a 1:1 molar ratio. In contrast, if one is reducing an anhydride or diester (to the diol), a 1:1 molar ratio of substrate to LAH would result in no remaining hydrides and most likely an incomplete reaction.

**NOTE:** For direct addition, LAH was added to the solvent in the nitrogen-purged reaction setup before the other reactant. Here, there are two safety issues. First, alcohol or water traces in ether, or THF solvent, or even condensed water may react strongly with LAH. One can start a fire by pouring such a solvent onto a quantity of LAH, then it combined, there is a heat of solvation. Therefore, once more, if one begins to pour such a solvent onto a quantity of LAH, then it will catch fire and have disastrous effects. Therefore, once the first portion has dried the solvent, LAH is still added, little by little, to the solvent in the reaction flask.

- Take off the stopper or cap and use a solid addition funnel or solid addition tube to add LAH portion-wise while stirring. The reaction setup must be kept in an inert atmosphere while adding LAH. Replace the stopper when done. For dropwise (inverse) addition to the reaction mixture, a solution of LAH in THF can also be utilized; these solutions are sold by several suppliers. The solid addition tube developed by the Merlic group\textsuperscript{53–55} can be loaded with LAH in a glovebox and then attached to the setup for the large-scale LAH reduction.

Most researchers usually run reactions at 0.1 to 1 M in the key substrate. The issue with LAH reductions is that if they are too concentrated, a gel will form during the reaction or upon quenching. Therefore, the more diluted reaction mixture is better.
reaction flask to avoid transferring LAH via a simple funnel.

- Transferring LAH slurry via a syringe or cannula may clog the syringe or cannula. An SOP should be developed for syringe or cannula transfers to address clogs. The use of a larger-diameter cannula will help to prevent buildups and clogs from small particles of LAH. In the event of a clog, chilled ethyl acetate would probably be best for quenching.

- LAH has some solubility in ether solvents but tends to form a slurry when a relatively large quantity of the reagent is used. The LAH solutions in THF are also available through various vendors and can be directly used during the inverse addition to the reaction mixture.

- Add the substrate to the reaction vessel carefully at the desired temperature in small portions to control the reaction exotherm and to prevent substrate decomposition due to high heat. Just as LAH was added slowly (in portions) to the solvent, the substrate must be added slowly to the solvent/LAH solution. This is best done by dissolving the substrate in the inert solvent and using an addition funnel to slowly add the solution. The size of the cooling bath and time for substrate addition depend on the substrate’s reactivity and heat transfer capacity.

- Remove the reaction aliquot carefully and quench using water or ethyl acetate to monitor the reaction progress. This is often problematic as the alkoxy-aluminum species are not always hydrolyzed on silica gel. So, withdraw a drop of the reaction mixture using a needle, add a few drops of water in a small test tube, add a few drops of ether, mix, and TLC the ether layer. The use of GC and HPLC is recommended when the TLC method is not appropriate.

- Once all the substrates have been reduced, the reaction mixture should be cooled to 0 °C. Excess hydrides are quenched by adding ethyl acetate. The reaction is quenched (hydrolysis of alkoxy-aluminum species) by water in the Fieser procedure.

- Make sure your product is stable under these conditions and does not generate any additional product from ethyl acetate. After the quenching is over, the product should be isolated by filtration or extraction using appropriate solvents.

- To avoid any difficulty during an LAH workup (emulsion formation, etc.), a Fieser workup is recommended.

### 3.1. Fieser Workup for LAH Reduction

Once the reaction mixture has been diluted with ether or THF, it should be allowed to cool to 0 °C. It is best to add a small amount of water at a time. Add the required 15% sodium hydroxide to this mixture in the second step. After thoroughly mixing the ingredients, let them sit for 15 min at room temperature. The needed anhydrous magnesium sulfate should be added to this mixture in the third stage. Stir the mixture for 15 min, then filter the mixture to remove any salt.

### 3.2. Example LAH Reduction

#### 3.2.1. (4S,5S)-2,2-dimethyl-1,3-dioxolane-4,5-diylmethanol

A flame-dried flask equipped with a reflux condenser containing LAH (4.058 g, 106.9 mmol) and a stir bar was flushed with nitrogen, and then anhydrous THF (38.0 mL) was added (note: a safer method would be to add LAH to a stirring solution of THF). The flask was cooled to 0 °C, and then a solution of dimethyl (4R,5R)-2,2-dimethyl-1,3-dioxolane-4,5-dicarboxylate (7.778 g, 35.6 mmol) in THF (19.0 mL) was added dropwise. The mixture was stirred at rt for 30 min and then at reflux temperature for 3 h. The mixture was cooled to 0 °C and diluted with diethyl ether, and water (4.1 mL) was added dropwise, followed by 15% aqueous NaOH (4.1 mL), then another portion of water (12.2 mL). The solution was warmed to room temperature, stirred for 15 min, and then MgSO₄ was added until the reaction mixture became white. The mixture was further stirred for an additional 15 min and then filtered through Celite. The solvent was removed in vacuo. Column chromatography with 100% ethyl acetate gave 4.461 g (77% yield) of the known clear colorless oil.

Most accidental fires and runaway reactions occur during quenching reactions, where excess LAH is used or the consumption is not complete. Therefore, extreme precautions must be used when quenching an LAH reaction. The quenching of an unreacted LAH using water should be done with caution during the reaction workup because it will release hydrogen gas, which will generally result in foaming. The size of the reaction flask should be enough to hold the solvent and quenching material to avoid spills. The alumina salts generated during the hydrolysis can form a paste that is challenging to separate from
the product and becomes difficult to stir when too much water is added. The addition of anhydrous magnesium sulfate to the mixture may dehydrate the hydrated alumina to provide a free-flowing powder (Fieser Workup). Applying a thick layer of a Celite pad to the fritted funnel to filter the ran mixture will avoid clogging the funnel from aluminum salts and other side products.

4. SAFETY CONSIDERATIONS

4.1. Emergency Preparedness for Working with the LAH Manipulations. Safety awareness and preparedness are critical components of any safety management system and should be reviewed before working in the lab (Table 2).

<table>
<thead>
<tr>
<th>items</th>
<th>yes</th>
<th>no</th>
</tr>
</thead>
<tbody>
<tr>
<td>all safety information on LAH and the substrate from a literature search and their SDSs have been collected, reviewed, and understood</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>chemical reactivity, incompatibility, and process safety issues have been examined</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>all appropriate PPE is available and properly used</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>a flame-resistant lab coat is available</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>leather, closed-toe shoes are worn</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>an appropriately sized bottle tote safety carrier is available</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>a class B and D fire extinguisher and a dry sand bucket are available</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>eyewash and safety showers are available</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

A spill involving LAH will require quick attention, because it may ignite. When a small quantity of LAH is spilled, the material should be covered immediately with dry sand or calcium oxide to prevent any ignition.

Using noncompatible materials should be avoided for spills involving LAH to prevent additional complications (Figure 10).

4.2. Exposures. The exposure of skin, eyes, and mucous membranes to LAH dust is corrosive because LAH will react with water to form hydroxides. And any significant quantity of LAH landing on the skin is likely to ignite and result in significant burns.

4.2.1. Real Incident. A blob of burning LAH powder hit a student’s neck burning the skin, then landed on the shoulder, and burned through the FR lab coat. Burning LAH is hot! (a reference to this information is not available)

4.3. Spills and Decontaminations. 4.3.1. Small Spills (Less Than 0.5 g LAH). Researchers should clean up any small spills inside a chemical fume hood if they are properly trained and fully aware of the properties of LAH. Cover the spill with dry sand or other noncombustible material, and whenever possible, prevent the entry of LAH into laboratory sinks. If there is no potential for fire or exposure, then proceed with cleaning and decontamination. Dry powders or a class D fire extinguisher should be used for any LAH fire. Avoid using a CO₂ extinguisher because LAH reacts with carbon dioxide and will spread the fire.

4.3.2. Large Spills. Procedures and practices should be implemented to prevent any large spills from occurring outside of containment. Prior to performing any work, however, the local EH&S team should be consulted on the appropriate procedures should a large spill occur.

4.4. Decontamination of Glassware and Other Items. Destroy residual LAH using ethyl acetate and finally with water before taking the glassware out of the chemical fume hood (prudent practice). When performing manipulations inside a glovebox, it is necessary to clean the working surfaces, the weighing balance, and other items. This LAH decontamination procedure applies only to small-scale LAH manipulations, and decontamination for large-scale manipulations may differ.

5. STORAGE OF LAH

During storage, containers should be kept tightly closed in a dry and well-ventilated place. Regularly monitor the cabinets and containers for any deterioration. Store separately from strong acids, alcohols, powdered metals, and water. The container’s hazard communication label must state “Water Reactive.” During storage, LAH should never come into contact with water or water-containing compounds.

6. WASTE/UNWANTED MATERIAL DISPOSAL

The large unused quantity in a reagent bottle should be disposed of through the Environment, Health, and Safety Department. Researchers should not quench larger quantities of unused LAH or other pyrophoric reagents to help their EH&S. Such quenching would violate waste laws.

LAH hydrolysis, or quenching, is generally carried out by slowly adding ethyl acetate to a solution of LAH in an inert ethereal solvent, followed by adding an ammonium chloride solution to the mixture. Never pour unreacted LAH into the solvent waste container. Large quantities of LAH should not be quenched in the laboratory for disposal purposes due to the potential hazards. Collect LAH was collected in a separate container with an appropriate label for proper disposal.

7. CONCLUSIONS

Safe manipulation of lithium aluminum hydride (LAH) involves proper experimental design, risk assessment, and emergency preparedness. Risks are reduced or eliminated by being aware of...
them before the beginning of manipulation. A risk assessment should be completed to identify all risks associated with the procedure and to determine how to control, reduce, or, if possible, eliminate the risks. Based on the risk assessment, appropriate methods and techniques for handling LAH should be developed into a reaction-specific SOP using this guidance document and additional resources available in the literature. If you are not aware of the potential process risks, review the possibilities with your PI, your chemical hygiene officer (CHO), the university environment and health resources, or other lab colleagues who may be familiar with similar chemistry or processes. A superficial search for hazards posed by chemicals is not sufficient.

While working with LAH, maintaining good laboratory housekeeping is also key to preventing unwanted events, such as chemical spills, exposure, and fire. The chemical fume hood and glovebox should be kept clutter-free for good access and to prevent unwanted events. Prudent laboratory practices should be employed during the reaction, storage, and disposal of LAH and LAH mixtures. You need to consider how the chemicals are used and look for potential interactions among different materials. Finally, use the information from your research about the safety of the reactions to develop an SOP that documents the precautions that must be taken. Make sure that everyone working within the lab has been given a complete orientation of the laboratory so that they are familiar with the location of all emergency equipment (i.e., eyewash stations, safety showers, and fire extinguishers) and laboratory policies.

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CRediT: Jeffrey P. Zebrowski formal analysis, methodology, resources.

**Notes**

The views expressed in this manuscript are those of the author and do not necessarily reflect the views of the organizations we have worked for or are now affiliated with. We illustrated our points using accessible literature and our experience working with LAH. This article should not be used as the entire source of training for any procedure, method, or task; rather, it should only be used as a guide. Any remarks or references to commercial goods, trade names, trademarks, producers, distributors, or anything else are merely for illustration purposes and do not imply a recommendation of any specific product or service. The authors declare no competing financial interest.

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**DEDICATION**

*This article is dedicated to Ralph Stuart III, past chair and membership chair of the Division of Chemical Health and Safety (DCHAS), for his outstanding influence on academic health and safety.*

**REFERENCES**


