Lithium Metal Fire and LiOH Exposure June, 2015

Incident Report and Lessons Learned

What happened?

A small, contained but intense fire occurred in a laboratory sink on 2nd floor Ottensman Hall at the University of Wisconsin-Platteville. This occurred as a result of a PI preparing to slowly quench the contents of 2 plastic bags containing ~10 g waste circular punched foil pieces of old, thin, 1 cm diameter lithium foil (lithium, far less reactive than sodium, is a water-reactive metal that reacts producing hydrogen gas upon reaction). This material was used for some previous battery research in our labs. The old lithium had been exposed to humidity over time in the bags and the foil punches were covered in a fine but thick white powder. This white powder is well known by chemists to be a mixture of lithium hydroxide. Initially, a few grams, perhaps 20 of the small disks, covered with powder from a first bag were dropped into a half full 1 liter beaker of cold water a few at a time. They fizzed and dissolved, making a dilute lithium hydroxide solution that can then be disposed of. A second small Ziploc bag was lifted over the sink area and broke open, spilling the contents down into the sink drain and beaker.

The heat generated melted the lithium and the resulting fire column *"30 second jet of flame from drain, above and below sink due to the trap cracking"* from the sink quickly extinguished itself, but created quite a bit of smoke that got into the ventilation system. There was minimal damage to the sink or surrounding area save burns in the floor tile and a broken glass sink trap. Burns range from pinhole size to ½" diameter w/ similar small burn spots on surrounding countertop. No injuries were sustained beyond mild eye irritation. Nine employees, including the PI and a student employee in his lab, were taken to the ER for observation due to exposure to airborne lithium hydroxide.

A student-employee on the project, on the other side of the lab, grabbed a nearby lab fire extinguisher but it was not needed (the fire extinguisher was expired by two years). The fire was out, the smoke, small at the time, was up near the ceiling of the lab, similar to what happens if you burned some toast at home (a UW-Platteville facilities employee, noticed the smoke from about 10 yards away, entering the hallway at this time). The PI immediately started to clean up the sink and floor and discovered that the glass trap under the sink had cracked from thermal shock as the hot lithium metals reacted with water at the surface of the glass. After a couple of minutes, the smoke alarm in the building, sounded. That alarm originated in the air handler associated with the HVAC equipment, detecting LiOH particles.

The PI immediately called campus police after the alarm went off to tell them there was no fire anymore and it was out, there was no immediate danger and no fire, but just the smoke in the room.
The student was sent out of the lab and building before the smoke became significant as the PI prepared to leave the building. The student had virtually no exposure to the chemical smoke as it had not materialized where he was or in the hallway until after he left the building. PI experienced mild exposure as did other staff. After this, the white smoke in the room began to become increasingly "dense." The white fog began to intensify and spread further thru the ventilation system and hallways. The fog was suspended in air and as emergency vehicles arrived, the smoke was circulating around the second floor. It continued to collect humidity, becoming much thicker.

What was the cause?

Metals such as lithium are always stored separately from other materials. In this case the lithium was stored in a dry "glovebox" filled with nitrogen and no water exposure. The glovebox had been unused for a while and humidity has caused the white powder to form on the lithium. The lithium was in a plastic ziplock bag in the glovebox and was removed to retask and move the glovebox to another lab. Hence the need for lithium disposal.

While transferring individual chunks/pieces of lithium to a beaker of cold water (standard disposal method for old lithium), the bag broke and multiple pieces of lithium (approximately 5-10 grams) fell into the beaker and sink trap simultaneously due to clumping of the metal. The resulting local concentration of lithium melted, caused the beaker to break and a small fire to start. A significant amount of the bag went into the drain and became lodged in the glass trap heating it and splitting the glass trap. The small fire from the broken beaker ignited hydrogen coming from the sink trap and the resulting plume of flame aspirated the white powder into the air at the ceiling of the room and into the ventilation system. The resulting hydrogen flame coming from the lithium reacting in the glass trap area was fed by air from the bottom of the broken trap and momentarily demonstrated torch like behavior before extinguishing itself. Significant expulsion and dispersion of the surrounding powder therefore occurred.

Despite the fire being out for minutes, the white powder, lithium hydroxide, which is highly hygroscopic) continued to absorb water from the 92% humidity in the air. The fact that the initially limited amount of smoke observed became observably thicker is consistent with small powder particles circulating and absorbing more and more humidity and becoming therefore larger and larger as more water forms bigger droplets. These heavy droplets then “hung around” and became difficult to remove from the building via the HVAC system.

Little Potential for Any Dangerous Residue and Exposure in the Building-Post Incident: Carbon dioxide in the air should fairly quickly neutralize any of the white powder and form chalk-like dust particles and inert lithium carbonate on building surfaces and in building filters, if indeed any is remaining. A simple pH test of a water wipe can assess/verify this.

What was done correctly?

- The researcher and students exited the building when the alarms went off and waited for emergency responders.
- Proper street clothing, closed toed shoes, gloves and safety glasses were worn during the incident.
- Water reactive chemicals are normally used and stored under an inert atmosphere in a glove box or other method that reduces exposure to moisture in the air, particularly during the humid months of summer.
- There was very limited combustible materials nearby such as paper and lab notebooks away from operations involving reactive and flammable chemicals near the sinks.
- A fire extinguisher was nearby and ready to be used if needed (as noted, the fire extinguisher was out of date)
- The building HVAC was adjusted quickly in order to best vent out the LiOH fog.
- Fire department response with SCBA was appropriate for an uncertain situation. After it was determined that HVAC systems were unable to adequately vent, the fire dept. opened roof access doors and set up fans to assist with venting.
- The evacuation response and subsequent reduction of access to floor and lab were appropriate.

How can this be prevented and what was done wrong?

- The sink area should be decluttered before such an operation and an appropriate secondary containment vessel should be utilized and material transferred from there.

- A lab coat should have been worn and was not.
- Lab safety goggles were removed prematurely since the fog was intensifying-even though the fire was out.
- A flat glass cover for the beaker to prevent splattering was not available and should have been.
- Previous disposal/neutralization of other much more reactive metals such as sodium has been done by the researcher in chemical hoods, in a coffee cans with wet sand and where water is squirted from a squirt bottle slowly and sequentially onto the metal until it stopped reacting, then repeated. T he PI underestimated the potential hazards. The quantity of lithium "hidden" in the white powder was significant and quickly melted, concentrated and ran down into the drain. Lithium should be treated with the same respect one affords sodium and potassium and not taken lightly.
- Such lab operations should be conducted in a fume hood and the sash could be pulled down when fire started. There are no accessible hoods on 2nd floor so no such work should be attempted there.
- Quenching of small amounts of alkali metals for disposal has alternatives such as to have chemical waste pickup of unneeded alkali metal, provided that the metal is stored under mineral oil and/or an Ar atmosphere.
- *We should consider whether a Class D fire extinguisher should be available prior to beginning work with alkalis.
- Ensure that a standard operating procedure (SOP) approved by the PI is established for the researchers with potentially hazardous processes. Preliminary consultation with a colleague would be beneficial.
- University Emergency Mgmt should have an immediate point of contact in order to determine the hazards associated with the chemical involved. PI was not clear in his explanation or truthful about the nature of the incident. This led to initial uncertainty in communicating hazards to emergency personnel and university staff.
- In a school-year situation, this disruption would have been much greater. Emergency Mgmt will need to assess the situation and direct personnel with rapidity to decrease confusion and allow alternate plans to be made for staff and classes.
-

What corrective action was taken or will be taken?

- The lab has no more reactive metals in 208 OTTS and the glovebox where the lithium was used and stored has been moved to 318 OTTS, a room with ventilation hoods.
- A cleanup plan will be developed to be submitted for input and approval to risk management, chemistry department Chair, and Assistant Dean
- Risk Mgmt will facilitate a discussion with the Chemical Hygiene Officer (CHO) and Chemistry Chair in order to update the Chemical Spill Response Checklist. This plan should be made available on the RM and Chemistry website and be shared with University Police and city of Platteville fire departments.
- The RMS and CHO will initiate a chemical hygiene inspection plan that includes all labs annually. (it has been more than 18 months since the last inspection of OTTS – an inspection would have noticed the clutter and expired fire extinguisher)