The Chemical Safety Mechanism
University of Wisconsin-Madison
Office of Chemical Safety

Lessons Learned: A Laboratory Explosion

Recently a campus researcher was performing a distillation of a chemical reaction mixture under inert atmosphere when the glass flask exploded resulting in lacerations on the individual's hands, arm, face, and chest. The explosion also caused a fire in the fume hood and the researcher singed parts of his clothes from the flames. Fortunately the injuries were not serious and the explosion was contained within the fume hood. Members of the Environment, Health & Safety Department (EH&S) investigated the causes of the explosion and reviewed the actions taken before and after the incident to see if lessons could be learned from this event. Though in this particular event it could not be determined what specifically caused the explosion a number of take-home messages were identified.

Figure 1: Contents of Fume Hood after Explosion

The researcher was performing a chemical synthesis using lithium aluminum hydride (LAH) based on a procedure published in the literature. LAH reacts violently with water, can ignite in moist air, and also decomposes to potentially explosive products above 125^{o}C. While these are known hazards associated with LAH, chemical reductions involving LAH are relatively common procedures in synthetic chemistry and can be performed safely using some standard techniques. The researcher was experienced with the procedure and took precautions to reduce the risk. The reaction was performed under an inert nitrogen atmosphere using standard Schlenk line (vacuum gas manifold) techniques, all glassware was dried prior to assembly, and solvents were freshly distilled to remove oxygen and residual water (again, a common procedure). In fact, the reaction was thought to have been completed and the product was being isolated when the explosion occurred.

Positive Actions

In addition to the experimental precautions taken, the researcher took other positive steps. The experiment was tested initially at a smaller scale, though it was not brought to the stage where the explosion occurred. The fume hood was designed with horizontal sashes and these were placed in front of experimental set-up for protection. It is evident that the sashes were able to contain much of the blast; however, the explosion occurred while the researcher was attending another experiment on the other side of the fume hood so at least one of the fume hood's four panels was pushed open for access.

Figure 2: Safety Glasses Worn by Researcher. Some of the areas of impact have been highlighted.

The researcher was wearing safety glasses at the time of the explosion and this most likely prevented more severe injury (see Figure 2). After the injury the other laboratory staff reacted quickly – attending to the researcher's injuries, putting out the fire, and calling 911. Both the UW Police Department and the Madison Fire Department responded quickly.

Incident Concerns and Observations

In addition to determining a possible explanation of the blast, the review also identified potential concerns related to the operation of the laboratory. The identified concerns did not necessarily contribute to the accident or its severity but they are worth noting.

- No Standard Operating Procedure (SOP) was documented for this experiment thus the safety precautions required were not written anywhere. While often in a research laboratory experiments vary from day-to-day, this does not negate the need to perform and document a hazard assessment for each operation.
- As stated above, the researcher had his safety glasses on but removed his cotton laboratory coat prior to the explosion. Fortunately the researcher was wearing a cotton-fiber long sleeved shirt and not a shirt made with a more flammable synthetic fiber. While the exact cause of the explosion is not known, LAH itself is potentially explosive and presents an additional fire hazard when it is used with flammable solvents such as diethyl ether. Under these circumstances the use of a flame-retardant lab coat (such as one constructed of Nomex™ or treated cotton) would be better suited. Additionally, while the safety glasses worn by the researcher may have prevented significant eye injury LAH is reactive enough that a face shield is highly recommended for this type of experiment since it provides additional protection.
- The synthetic preparation was based on a published journal article. No indication was given of any instability of the product. However, in doing a more thorough post-incident review of the literature there have been at least two reported cases where aluminum compounds with perfluorophenyl substituents have been identified as potentially explosive. Whether similar compounds may have formed as side products during this incident could not be determined, but knowledge of these other reports could have served to put the researcher on a higher level of alert.

Lessons Learned

While the chemical synthesis that was performed is not likely to be performed by others on campus, there are some general lessons that can be applied elsewhere.

- Do a thorough review of all planned procedures prior to beginning and identify all the potential hazards. A superficial search of the hazards posed by chemicals is insufficient. You need to consider how the chemicals are used and look for potential interactions between different materials. From there, determine ways to reduce the risk. And finally use the information to develop an SOP that documents the safety precautions that need to be taken.
- Do not let your guard down. In this incident the explosion occurred after it was thought that the reaction was complete. Continue to wear the appropriate PPE until the process is completed.
- Each lab should have established policies outlined in their lab-specific Chemical Hygiene Plan. In this example the outcome could have been much worse had no one else been around. Work with hazardous compounds or procedures should not be performed alone.
- 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 safety features (for example, eyewash stations, safety showers, and fire extinguishers) and laboratory policies.

Incidents like this should be a wake-up call. Accidents can and do happen – even when you identify hazards and take precautions.

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