UCI Environmental Health & Safety

Lesson Learned

Zinc Chloride Fume Release

April 2025

What Happened?

On April 21st, 2025, around 12:30pm, a graduate student researcher in a laboratory on campus was conducting a first-time experiment as part of his thesis. The incident occurred while he was performing a fluxing reaction with an aluminum alloy (melting point 650°C), and zinc chloride powder (melting point 290°C) as the flux. He put 403 grams of solid aluminum alloy pieces into an aluminum oxide crucible, layering 298 grams total of zinc chloride throughout it in multiple alternating layers. The crucible was placed in a radiative box furnace and the temperature was set to ramp up to the desired temperature of 715°C, which would melt the aluminum and flux. When the furnace reached 400°C, the researcher left the sample unattended for about an hour. When he returned, he asked his colleague not to enter with him, knowing that this process is known to create hazardous fumes, donned PPE (flame-resistant lab coat, safety glasses, full face shield, P100 respirator), entered, and saw that the temperature of the furnace had risen to about 615°C. He noticed that minimal fumes were visible at the seams and vent of the furnace. He put on heat-resistant gloves and opened the furnace to check on the sample and a plume of white smoke immediately formed and blocked his view. He used tongs to pull the crucible out, place it quickly on a bench, and evacuated. The smoke alarm activated shortly after he left the lab and was on the phone with his supervisor. The researcher had not been fit tested through UCI for the use of the respirator.

Direct Cause:

Heated zinc chloride reacted with air/moisture to create hazardous hydrogen chloride and zinc oxide fumes.

Root Cause:

The risks of heating and using zinc chloride as a fluxing reagent were not adequately assessed. Zinc chloride is known to create hazardous fumes when heated above melting point and exposed to the atmosphere.

Primary factors that contributed to the incident:

An excessive amount of material was used for the first-time experiment and engineering controls were not adequately in place. The researcher also left the furnace unattended and removed the crucible from the furnace upon returning, which continuously exposed the material to atmosphere and increased the scale of the release.

What steps can be taken to prevent this type of incident from occurring again?

- Thoroughly research the use of new materials or the use of known materials in new processes before performing experiments to ensure that they can be done safely. Conduct risk assessments of materials involved, including potential outcomes upon heating and manipulation, as well as potential byproducts. Ensure adequate research is done and that known hazards are identified and controlled.
- Start experimentation with small amounts to test methodology before increasing scale. In this case, the researcher had never performed a fluxing reaction and had not worked with zinc chloride before.

- Ensure that materials that readily react with air/moisture, either at room temperature or upon heating, are worked with in a fume hood or kept contained. Removing the crucible from the furnace during this experiment exposed it to the atmosphere readily, where it continued reacting and releasing a lot of fumes. In the event of a hazardous fume release in a furnace or otherwise vented equipment, it is recommended to keep the door closed, turn off the heat, and unplug the unit immediately before evacuating.
- New experiments should be conducted using a standard operating procedure (SOP) that includes provisions for deviation and experimental trials. The SOP should include all hazards associated with the individual components, the process, and any potential byproducts, in addition to required engineering controls and PPE.
- Ensure that all personnel using respirators have been properly fit tested and trained.

For more information or assistance, please contact EHS at (949) 824-6200 or at safety@uci.edu.