

SHARED SPACES, SHARED RESPONSIBILITY

Unexpected Hazards in Collaborative Lab Work

This Lessons Learned Document focuses on an incident in which a furnace began releasing irritating vapors when a researcher ran an experiment in a different lab than they were used to. This incident revealed gaps in both labs' safety procedures, highlighting the importance of re-assessing risk when working in a new location and reviewing procedures from lab visitors.

What Happened?

A researcher ("Researcher A") was working on a synthesis that involved heating a mixture of antimony acetate, citric acid, and iron nitrate in an open crucible in a box furnace. Their lab's ("Lab A") box furnaces were inoperable at the time, and could not be repaired in the near future. The researcher, however, had a deadline they had to meet by the end of the week, so they reached out to a neighboring lab ("Lab B") that also had a box furnace and asked to use it. The neighboring lab agreed, so the researcher met with a researcher from the lab "hosting" their experiment ("Researcher B") and gave them an explanation of their experiment, including that it was low hazard. Researcher A gave their sample to Researcher B, who placed it in the furnace, programmed the furnace, and started the procedure.

Some time after the procedure began, Researcher B and a colleague from Lab B noticed an odor similar to vinegar. They had reserved time on an instrument, so they left to perform that work. When they returned, the odor was significantly stronger. They left the room, informed the rest of Lab B, and contacted Researcher A. Researcher A informed them that Environmental Health and Safety (EH&S) had reviewed the procedure two years prior and determined that the reaction byproducts were not toxic (though they could be irritating) in the small quantity produced, but all agreed that the procedure should be halted. They turned off the furnace, moved the sample into a fume hood, and allowed the odor to dissipate. They did not contact EH&S because they felt that based on prior risk assessments, their knowledge of the gaseous byproducts involved, and the relatively small quantity of materials involved that they could assess the situation themselves.

Why Did This Happen?

The direct cause of the incident was the release of acetic acid (formed from the acetate ion) and citric acid vapors from the sample due to the heat from the furnace. Acetic acid is the chemical in vinegar, explaining the odor. The furnace was not connected to an exhaust line, so the vapors dispersed into the room.

The root causes are more complex. This incident is a good example of the "Swiss cheese model" of incident causation: despite having multiple layers of safeguards, when "holes" in those safeguards coincidentally line up, an incident may occur. Here, a number of factors ("holes") aligned, leading to an incident involving two labs that take safety seriously and have multiple layers of safeguards aiming to prevent such incidents. If any of the below factors were different, the incident would have been significantly less likely to occur.

Ventilation

The most immediate contributing factor is the different ventilation setups in the two labs. In Lab A, their furnaces are plumbed to exhaust ventilation. As a result, while the lab is still cognizant of the hazards of the gaseous byproducts from their experiments, byproducts are not generally a cause for concern because they are removed by the exhaust. In Lab B, the furnace is not plumbed to exhaust, because it is primarily used for drying glassware and samples. In the uncommon cases where reactions are run in the furnace, they are run in sealed pressure vessels that are subsequently opened in a fume hood. This also means that the importance of ventilation in preventing cross-contamination of samples was different for the two labs. Exhaust ventilation was not necessary for Lab B's uses of the furnace. Neither researcher identified the possibility of the byproducts being an issue because they were so used to the standard situations of their own lab. If Lab B's furnace had exhaust ventilation, or if both researchers were better aware of the differences in their labs' setups, the incident may not have occurred.

Lab Policies

Both Researcher A and Researcher B technically met the policy requirements of both their labs regarding training, equipment usage, and risk assessment, but this incident revealed edge cases that showed the policies were insufficient. Lab A has a policy to review any planned procedures to be run in furnaces; in particular, they consider what the possible gaseous byproducts will be, and if the byproducts could be toxic, they discuss any additional safety precautions needed. In this case, the procedure was not reviewed because it had been reviewed in the past, with the conclusion that due to the small quantities of material used, hazardous concentrations of byproducts could not be produced. However, it had only been reviewed in the context of Lab A's specific setup, and the lab's policy did not require a new review for a new setup. If Lab A's policy explicitly required re-review of a procedure whenever the procedure is altered, the risk associated with the different ventilation configuration may have been identified.

Lab B had a policy that required any work performed in their workspace by researchers who are not members of Lab B to be reviewed by the lab's principal investigator (PI). Because Researcher B was going to be the person to actually perform the work, the lab's policy did not require the procedure to be reviewed. Furthermore, because the majority of the "procedures" conducted in the furnace were simply to dry things, there was no lab policy requiring the review of possible gaseous byproducts. If Lab B's policy had required all work to be reviewed or that reaction byproducts be listed on the furnace log, the risk associated with the gaseous byproducts may have been identified.

Other Contributing Factors

- Researcher A was faced with an approaching deadline and equipment difficulties. These made them feel stressed and rushed, so they were less likely to identify potential risks.
- Based on the prior collaborative review of the procedure between EH&S and the lab, which concluded that acetic acid would not form in hazardous concentrations (but possibly irritating), Researcher A considered the experiment safe, making them less likely to re-review the procedure. Researcher A's confidence in the safety made Researcher B less likely to consider the risks.
- Lab A's furnaces, already configured to operate safely for their work, were broken, and despite the lab's best efforts to get them repaired, no resolution was in sight.
- Typically, syntheses like the one Researcher A was performing require the reaction vessel to be covered. In this case, however, the vessel needed to be open to achieve the correct product

morphology; prior experiments had found that covering the vessel did not produce the desired characteristics.

What Went Right?

Ultimately, no one was injured and the incident only resulted in the loss of some sample materials. A number of factors contributed to ensuring this incident was not more serious:

- While the gaseous byproducts were irritating, they were not harmful in the concentrations present. In the past, Lab A had reviewed the procedure with EH&S, and the reviewers had concluded that given the quantity of material involved, the identity of the byproducts, and the high ventilation rate of all wet labs, the gaseous byproducts of the procedure could not reach levels toxic or corrosive to humans.
- Researchers from Lab B identified the cause of the irritating vapors and coordinated well with Researcher A to resolve the situation.
- Researchers from both labs were proactive in identifying root causes and safety improvements.

How to Prevent and Respond to Accidents Like This

EH&S has a number of recommendations for how labs can prevent and respond to incidents like this. Additionally, the labs involved came up with ways to prevent similar incidents. Here are the key recommendations from this incident:

- [Perform and document a risk assessment](#) before performing a new experiment, making significant alterations to an existing procedure, turning a process over to another user, or performing other novel tasks in the laboratory. Completing and documenting a formal risk assessment helps researchers to take a methodical, systematic view of their proposed plans, offering an opportunity to catch invalid assumptions and identify ways to protect against hazards. EH&S is always available for consultation regarding both when a formal risk assessment is appropriate and the contents of such an assessment.
- Labs should establish policies requiring review of “guest work,” both for outsiders coming to their lab and for lab members going to work in another lab. Changes to previously established procedures, whether due to unexpected challenges, new equipment, or unfamiliar locations, are common causes of incidents.
 - Policies should define certain hazards or risk thresholds that require review by the PI.
- Establish user logs for shared pieces of equipment. When equipment use may involve hazardous substances, the log should require users to clearly list the materials used and any possible hazardous byproducts.