LESSONS LEARNED MEMO

EXPLOSION IN A CHEMISTRY RESEARCH LAB USING DISTILLATION FOR FINAL PURIFICATION OF TOSYLATED COMPOUND

What Happened:

A flask exploded inside the fume hood when a chemistry graduate student at FRH was in the process of purifying a tosylated alkyne compound using a vacuum distillation. The student had completed the tosylation reaction involving 20 grams of 4-pentyn-1-ol with 50 gram of p-toluenesulfonyl chloride in the presence of 36.5 ml of triethylamine and 250 ml of di-ethyl ether. A peroxide test strip indicated that the peroxide level within the ether container was less than 0.5 ppm. After completion of the reaction, the triethylamine/HCl salt was filtered and the remaining mixture was placed in a rotary evaporator and the liquid volume reduced to 50 ml. The mixture was then placed in a 100 ml flask under vacuum at 120-130 degrees centigrade for the distillation process.

The explosion occurred as the student was raising the fume hood sash to lower the temperature setting on the hotplate after observing that the liquid mixture inside the flask turned black in color.

The student received a small cut on the forehead from the broken glass and a first-degree burn on the left arm from the hot silicone oil. The ceramic top of the magnetic hot plate and the 100 ml distillation flask shattered into pieces; however, there was no structural damage.

The student was using safety glasses and nitrile gloves at the time of the incident.

What Was Learned:

Tosylation is commonly done in organic chemistry labs without any incident. This was an isolated case most probably because distillation was used as a final step, which is not a typically used procedure for its purification. The alternative column chromatography procedure for final purification should have been used; one should consider distillation free procedure as a method of choice.

It is preferable to avoid the use of ethers at any stage of a reaction in which distillation is performed. Even though the bottle of ether used in this reaction has inhibitor in it and the measurement of peroxides turned out to be less than 0.5 ppm, the peroxides can easily concentrate as volatile solvents are removed during rotary evaporation and distillation to the extent that it can explode. If you choose to distill peroxide-forming solvents, please familiarize yourself with the associated hazards prior to distillation. In certain operations, ethyl acetate can usually be substituted for ether.

Some of the sulfur esters are thermally unstable, especially the esters of unsaturated alcohols. They are likely to polymerize in the presence of liberated acids as a catalyst. Acetylene groups are also suspect for explosive instability since a wide range of acetylenic compounds are prone to explosive polymerization. The observed color change in the distillation flask from clear to black right before the explosion is probably indicative of a runaway reaction or polymerization.

Incident Root Cause:

The root cause of the incident was inadequate hazard evaluation of the available purification methods. Each method should have been analyzed for their hazard potential, especially when the student opted to use a heated method to purify the solvent instead of column chromatography.

Recommended Corrective Actions:

1. Prepare a written SOP approved by the PI for all hazardous operations and follow it strictly. This becomes even more important when you're trying to scale up or vary the proven methodology for a particular reaction.

2. Evaluate the potential hazards associated with the experiment especially when there's a change in conditions or compounds that makes this a new procedure. A new hazard may be introduced as a result of side reactions. Consult additional sources such as Bretherick's Handbook of Reactive Chemical Hazards.

3. Do not raise the sash immediately when an unexpected event suddenly transpires inside the hood. Evaluate the process and if the operation is heated disconnect the power to the experiment from <u>outside</u> of the hood.

4. Always use appropriate Personal Protective Equipment (PPE) like gloves, lab coat, and safety glasses when working with hazardous chemicals; you may need to upgrade to goggles, face shield, etc. where there's a potential for explosion or fire.

5. Never work alone while handling hazardous materials or operations.

6. Know in advance how to use safety equipment such as fire extinguishers and their location. Make sure the fire extinguisher is appropriate for the hazards in the area.

7. Know in advance how to access medical care properly during emergencies at UC Irvine. Use 911 calls for transporting injured employee after an explosion or fire where condition of the employee could be life threatening.

8. The location of hazardous operations must be properly and adequately separated from hazardous materials storage areas.