Stories of Laboratory Incidents That Teach Us About Safety

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“What Did You Do?”

- 1st job in laboratory – laboratory assistant
- Prepared chemicals/solutions for laboratory experiments for other students
- Early task – make 2 liters, 12 N, sodium hydroxide, using 2 liter glass beaker
- May have worn safety glasses but no clothing protection
- Mom – “What did you do?”
“What Did You Do?”

• Lessons Learned
  • Working in labs can be hazardous
  • Don’t count on someone telling you about these hazards
  • Making concentrated NaOH generates heat, aerosol mists
  • NaOH really corrosive for people and materials
  • Need to be prepared for all sorts of hazards in the lab
Laboratory Research

- Involved in research >25 yrs – fun, meaningful, important
- Research by nature
  - Investigates new phenomena, processes, materials
  - Fluid process – Changes to adapt to recent results
  - Knowledge of hazards, risks essential – chemical, biological, & physical hazards, reactions, processes, equipment, behavior
  - Not understanding or ignoring safety, or taking unnecessary risks can result in undesirable incidents

“If we knew what it was we were doing, it would not be called research, would it?”
Albert Einstein
How Fast Can You Run?

- Trail leading to 2\textsuperscript{nd} floor lab
- Explosion – Severe injury
- Call from hospital
- Smoldering glove box
- “Wooshing” sound
- Oh my gosh! Run, Bob, Run
What Happened?

• Two Incidents

• 1st Incident – Explosion w/Severe Injuries
  • Peroxides formed on threads of vial containing chemical being used
  • Friction from twisting the vial cap set off explosive peroxides

• 2nd Incident – Fire, Near-Miss
  • Disturbing the damaged glove allow air to enter glove box
  • Air-sensitive chemicals in glove box ignited upon contact with $O_2$
  • Fire shooting out of glove box used up $O_2$; fire went out
  • Fire extinguisher powder prevented further fires; allowed cooling
Lessons Learned

• Research can be dangerous, if do not recognize/understand hazards
• Lab incidents can result in serious injuries
• It can happen to YOU and/or others!
• Must learn about laboratory safety
• Must care about safety – safety ethic
• Must think critically about safety
Interest in Laboratory Health, Safety

- Research on occupational, environmental health
- Realized didn’t know much about safety – I didn’t know that I didn’t know
- Safety education: Missing in chemistry curriculum
- Puzzled, asked why?
- Finally heard “If I knew what to teach...”
- Decided to write lab safety textbook
RAMP Up For Safety

• The Four Principles of Safety
• Remember acronym – RAMP
  
• **Recognize** hazards
• **Assess** the risks of hazards
• **Minimize** the risks of hazards
• **Prepare** for emergencies

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Using RAMP

- **Recognize (and understand) hazards**
  - Chemical, biological, physical, reactions, processes, equipment, behavior
- **Assess the risks of the hazards**
  - How could you be exposed
  - What would be consequence
- **Minimize the risks of the hazards**
  - Plan how to minimize/control hazards
- **Prepare for emergencies**
  - Think about emergencies before they happen
  - Know how you will respond
RAMP in Incident Investigations

• Incident # 1: “What did you do?”
• Incidents #2, 3: “How fast can you run?”
  • Failed to recognize hazard; assess risks of hazard; minimize risks of hazard; prepare for emergencies

• Think about RAMP as you hear the other incidents!
Safety Vaporized

- Graduate student conducting research
- Hood cluttered; worked on open bench
- Used hot plate, open beaker, ether solvent
- Click and flash!
- Didn’t recap ether – now on fire!
- Another student extinguishes fire
Why Did This Happen?

• Hood cluttered – time important, not safety
• Missing: Knowledge of safety, Positive safety attitude (ethic)
• Student did not:
  • Understand need for good housekeeping
  • Recognize or understand the hazards
  • Understand conditions for fire
  • Think about ignition sources
  • Minimize presence of flammable vapors
  • Minimize volume of flammables
  • Think critically about safety
Lessons Learned

• Laboratory work – dangerous IF hazards are not recognized, understood, assessed, minimized

• Intimate (not casual) knowledge of hazards of chemicals being used is required, especially in research

• Being prepared for emergencies critical for survival

• Chemical/laboratory safety education – essential for laboratory scientists
What You Don’t Know Can Hurt You or Somebody Else

• New lab employee
• Prepared formalin solution; spilled in sink, leaves lab
• Senior employee returns unaware of spill
• Shortness of breath; requires emergency care
• Sensitized to HCOH
• No longer work in lab
What Happened?

• Formalin spill allowed formaldehyde to escape into lab air

• New scientist did not recognize or understand formalin/formaldehyde hazards

• Failed to take emergency actions to clean up spill

• Failed to notify anyone of spill

• Inaction resulted in unrecognized exposure of another employee

• Exposure caused loss of lab job

Formalin
- Aqueous HCOH (37%) solution with methanol (10%) preservative
- Paraformaldehyde – trimer of formaldehyde
  - B.P. 96°C
  - Formaldehyde vapors released easily

Formaldehyde – HCOH
- Colorless gas w/ pungent odor
  - b.p. -19°C; v.p. 10 mm Hg at – 88 °C [flammable gas]
- Human carcinogen, sensitizer, irritant, lachymator
Lessons Learned

• Ignorance of safety, lack of safety knowledge and safety ethics can be dangerous to you or others

• Essential skills
  • Recognizing and understanding hazards
  • Understanding how to assess risks of hazards
  • Understanding how to minimize risks of hazards
  • Being prepared for emergencies

• Your actions can adversely affect you or others
Why Do Incidents Occur?

• **Root cause:**
  • An underlying cause of an incident
  • Can be multiple root causes

• To find root cause:
  • Ask why (x5)
  • Conduct root cause analysis

• Prevent/minimize future incidents by addressing root causes
What You Don’t Know….

• Why was there an injury?
  • Spill not cleaned up

• Why?
  • Didn’t recognize hazard; careless, non-thinking about safety

• Why?
  • Lacked adequate safety education, positive safety attitude (ethic)

• Why?
  • Academic institutions do not incorporate safety throughout curriculum

• Why?
  • Academic institution’s leadership/management in safety – inadequate or missing
Smoke Gets in Your Eyes

• Graduate student cleaning lab
• Residue of benzene dried w/ Na wire poured into sink
• Na catches fire, sets residual benzene on fire – burns w/ black, thick, sooty smoke
• Unforgettable, surreal scene – legs walking w/o a body
• Fire extinguished; no injury or significant damage
• A NEAR MISS
Lessons Learned

• Being careless with hazardous chemicals – dangerous
• Easy to underestimate risk
• Risky behavior – dangerous
• Need to learn from near misses
Smoke Gets in Your Eyes - Again¹

- Graduate student cleaning lab
- Destroys Na (?) w/ alcohol; pours residue in sink
- Na catches fire
- Fire ignites nearby solvents
- One lab destroyed, two other labs heavily damaged
- Students, post-docs lost all – notes, chemical products, equipment

Consequences of Laboratory Fire

- Damage: $400,000
- Renovations at $6.2 M
- Intense media coverage
- Fire department (FD) – Safety lacking at facility – “when you have repeated incidents ... you cease to be the victim ... you have to be identified as the problem.”
- FD unwillingness to put firefighters at risk
- FD defensive containment not aggressive attack.
- FD recommendations
  - Sprinklers, fire walls, second exits, renovate elevators, emergency power system, upgrade fire alarm, install appropriate chemical storage
- Costs: $30.2 M
Lessons Learned

• Incidents repeated over & over again
• Risky behaviors - Responsible for many incidents
• Ignoring or failing to address safety – dangerous, expensive consequences
• Sharing incidents with others could prevent future similar incidents
Shocking Experience!¹

• Researcher using high-powered laser, observed condensation on high-voltage power supply
  • Wiped with tissue, contacted anode carrying 17,000 DC volts

• Received terrific shock, burn

• Screamed, ran into hall – “I got a shock”

• Collapsed, no pulse, not breathing

• Officers gave CPR; EMTs used automated external defibrillator (AED)

• Survived!

¹ American Industrial Hygiene Association, Laboratory Health and Safety Committee, Incidents, Electrical Shock
Shocking Experience!

• Why #1 – Touched high-voltage power supply anode, electric current grounded through him

• Why #2 – Disabled safety measures – Risky Behavior!

• Why #3 – Did not use alternate protective measures

• Why #4 – Failed in recognizing hazard, accessing risk of hazard, minimizing risks of hazard;

• Why #5 – Not thinking critically about safety; Missing safety ethic
Lessons Learned

• Never disable/bypass safety measures
• Avoid risky behavior that puts you or others in danger
• Develop strong safety ethic – care about safety, ensure safety an integral part of one’s activities
• Build strong safety knowledge – so that
  • Hazards are recognized, understood
  • Risks of hazards are properly assessed and minimized
  • Preparing for emergencies is a normal, continuous process
Learning from Incidents

• Use incidents in teaching as case studies
  • Captures interest of students (and others)
  • Promotes thinking about safety measures

• Investigate laboratory incidents
  • Determine direct, indirect, root causes
  • Measures that minimize, prevent future incidents

• Establish system for reporting, investigating, sharing information about incidents
  • Includes all employee, student incidents, near-misses
  • Incidents and lessons learned should be shared
  • Consider publishing these or putting on website
Summary

“Concern for man himself and his fate must always form the chief interest of all technical endeavors. Never forget this in the midst of your diagrams and equations.”

Albert Einstein