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Three Safety Demonstrations

Acid in the Eye, Holey Socks, Flaming Vapor Ramp

Start with safety! Students will remember these demonstrations—and the important safety lessons they learn. In *Acid in the Eye,* demonstrate the immediate and irreversible destructive action of strong acids using egg whites as simulated eyes. Then, the dramatic *Holey Socks!* demonstration helps students remember why it is important to wear a chemical-resistant apron and closed-toed shoes when working with corrosive chemicals. Finally, the *Flaming Vapor Ramp* teaches about the invisible danger of flammable vapor.

I. Acid in the Eye

Introduction

Demonstrate the immediate and irreversible destructive action of strong acids using egg whites as simulated eyes.

Concepts

- Goggle safety
- Reactivity of strong acids and bases

Materials

Hydrochloric, sulfuric or nitric acid, 6 M or stronger	Petri dish
Sodium bicarbonate solution, 1 M (optional)	Beral-type pipets
Sodium hydroxide, 6 M or stronger (optional)	Overhead projector
Raw eggs or egg whites	Permanent marker

Safety Precautions

Hydrochloric, nitric, and sulfuric acids as well as sodium hydroxide are all highly toxic by ingestion or inhalation, and severely corrosive to skin and eyes. Remember that any food items brought into a laboratory setting are considered chemicals and should not be ingested thereafter. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Draw a large eye on the bottom of a Petri dish using a permanent marker.
2. Gently crack open an egg and separate the egg white from the egg yolk. Place the egg white in the Petri dish.
3. Place the Petri dish on the overhead projector stage.

Demonstration

1. Briefly discuss the similarities between an egg white and a human eye (see *Discussion* section).
2. Using a Beral-type pipet, place several drops of acid on the egg white. It will immediately become opaque.
3. Try to "undo" the damage by gently rinsing the egg white with water or dilute sodium bicarbonate solution. The egg white cannot be made transparent again.

4. Place the cover on the Petri dish and pass it around for the students to see that the egg white/human eye is permanently damaged. Ask the students what effect this would have on their vision. Before passing the egg white around, make sure there is no unreacted acid and caution the students against touching the egg white.
5. Repeat the experiment with other acids or sodium hydroxide solution. Concentrated nitric acid turns the egg white brilliant yellow, almost like an egg yolk. Strong solutions of sodium hydroxide do not discolor the egg whites but do solidify them. Acid solutions less than 6 M will work, but the effects are not as dramatic.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The egg whites may be rinsed with water and then placed in the trash according to Flinn Suggested Disposal Method #26a. Any excess acid may be stored in an acid cabinet for future demonstrations.

Discussion

Egg whites and human eyes contain an abundance of proteins. Proteins are natural polymers (also called polypeptides) formed by linking amino acids together. When subjected to strong acids, proteins undergo a process called denaturation in which they lose their native three-dimensional structures. The acid can further break down the proteins to amino acids via hydrolysis reactions. Proteins need very specific three-dimensional structures to perform their biochemical functions—denaturing or destruction of the protein structure changes the properties of a protein and is frequently irreversible.

This demonstration should convince your students of the importance of wearing chemical splash goggles anytime chemicals, heat or glassware are used. During the school year, a gentle reminder of "remember the egg white" should bring back vivid memories of this safety demonstration and the importance of wearing goggles.

Acknowledgment

Special thanks to John Brodemus, Richards High School, Oak Lawn, IL, and Lynn Higgins, Proviso East High School, Maywood, IL, for bringing this demonstration to our attention.

Materials for *Acid in the Eye—Safety Chemical Demonstration* are available from Flinn Scientific, Inc.

Catalog No.	Description
H0006	Hydrochloric Acid, 12 Molar, 2.37 L
N0055	Nitric Acid, 15.8 Molar, 2.37 L
S0145	Sulfuric Acid, 18 Molar, 2.37 L
AP3306	Standard Vented Chemical Splash Goggles
AP8739	Instructor's Chemical Splash Goggles
AP8955	Economy Choice Chemical Splash Goggles

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices

II. Holey Socks!

Introduction

Laboratory safety rules should include wearing a chemical-resistant apron and closed-toed shoes when working with corrosive chemicals. This safety demonstration offers dramatic evidence to help students remember why these rules are important.

Concepts

- Safety rules
- Personal protective equipment
- Acid safety
- Proper dress in lab

Materials

Sulfuric acid, concentrated, H_2SO_4, 18 M, 2–3 mL

Disposable glass Pasteur pipet or medicine dropper

Glass Petri dish or large watch glass

Sock, white cotton

Video camera (optional)

Safety Precautions

Concentrated sulfuric acid is severely corrosive to eyes, skin, and other tissue. Use only small amounts in this demonstration and be sure the sock is on top of a glass dish or plate. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Wear chemical splash goggles, gloves, and an apron to set a good example.
2. Place an old white cotton sock on top of a glass Petri dish, large watch glass, or other glass dish. *(The acid will eat through the sock very quickly and the glass dish is needed to contain the acid.)*
3. Obtain approximately 2–3 mL of concentrated sulfuric acid using a disposable glass pipet.
4. Slowly add sulfuric acid dropwise onto the sock. Place the drops next to one another rather than on top of one another. Try adding the drops in various places on the sock or in the shape of an "S" or "O."
5. Observe that within 20–40 seconds the acid will "eat" through the first layer of the sock, and then begin destroying the second layer as well. Within two minutes, there will be a hole completely through the sock. There may also be a dark ring around the hole where the acid has "burned" the cotton. The hole may continue to grow for a few minutes.
6. Repeat if necessary.
7. Take the sock and dish to the sink and carefully rinse both with a large amount of water.
8. Keep the "Holey Socks" as a reminder to wear chemical-resistant aprons and closed-toed shoes when working with corrosive chemicals.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The amount of acid residue on the sock and in the dish is minimal and may be rinsed down the drain with a large amount of excess water according to Flinn Suggested Disposal Method #26b.

Tips

- This activity uses hazardous chemicals to demonstrate an important safety rule. Follow all directions and practice the demonstration before presenting it to your students. The demonstration should reinforce good safety procedures.
- Old, unmatched, white, cotton athletic socks work great. The older the sock the better, because there will be less cotton to eat through.
- The sock must be lying on top of a glass plate or dish to contain the acid droplets and acidic remnants from the sock.
- A presentation video camera such as the Flinn ChemCam™ will provide your students with a close-up view of this and other demonstrations.

Discussion

Concentrated sulfuric acid is severely corrosive and also a powerful dehydrating agent. The rate at which the sulfuric acid eats through the cotton is a function of both properties. Less concentrated sulfuric acid solutions and other strong acids will work but will not be as dramatic. Of course, as most chemistry teachers will attest, weaker solutions of acids and bases can still ruin clothes. There are very few chemistry teachers who do not have a lab coat or pair of pants with holes from where they splashed a chemical on themselves or leaned against a lab counter.

The purpose of this demonstration is to visually and convincingly reinforce the safety rule to always wear a chemical-resistant apron and proper attire in lab. Proper lab attire includes sturdy, closed-toe shoes and a lab coat or long pants. Take the opportunity to remind students as well about the importance of wearing chemical splash goggles and chemical-resistant gloves. Goggles, gloves, and apron are examples of *personal* protective equipment—their purpose is to protect *students!* This may also be a good time to review the purpose and the location of the safety shower and how quickly it must be used in the case of an accident involving concentrated acids.

Materials for *Holey Socks!* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0228	Sulfuric Acid, 18 M, 100 mL
S0145	Sulfuric Acid, 18 M, 2.5 L
AP4560	Flinn ChemCam™ Camera

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

III. Flaming Vapor Ramp

Introduction

Vapors originating from volatile, flammable liquids are generally heavier than air and can travel along a countertop to an ignition source. Once the vapors have been ignited, the resulting flames will quickly follow the vapor trail back to the vapor source and may result in a very large fire or explosion.

Concepts

- Flammable liquids
- Combustion
- Fire safety

Materials

Hexane, 2–3 mL
Aluminum angle bracket, about 1 meter in length
Candle, tealight
Erlenmeyer flask, 1-L
Match or lighter
Ring stand and clamp
Stopper, 1-hole, to fit flask

Safety Precautions

Be very careful while performing this demonstration. Do not use more hexane than is specified in the procedure. Using more hexane many cause the flames to become too large and will also increase the fire hazard should the flask fall and break. Do not substitute a more volatile liquid for hexane; many volatile solvents are dangerously combustible, and the resulting vapor trail may enter the flask and lead to an explosion. Ether (diethyl ether) or methyl alcohol, for example, are far too volatile to use anywhere near an open flame or ignition source. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Clear off a countertop before starting. Remove all combustible materials such as paper from the demonstration area.
2. Prepare a "vapor ramp" by elevating one end of the aluminum angle bracket using a ring stand and clamp. The ramp should be at a 20° angle or about 20 cm elevation (see Figure 1).
3. Place an unlit, tealight candle on the countertop directly below the lower end of the vapor ramp (see Figure 1).
4. Pour about 2–3 mL of hexane into the 1-L Erlenmeyer flask.
5. Place a one-hole stopper on top of the flask and swirl the flask to evaporate the hexane. Allow the flask to sit for a few minutes to allow hexane vapors to fill the flask. Set the flask aside.

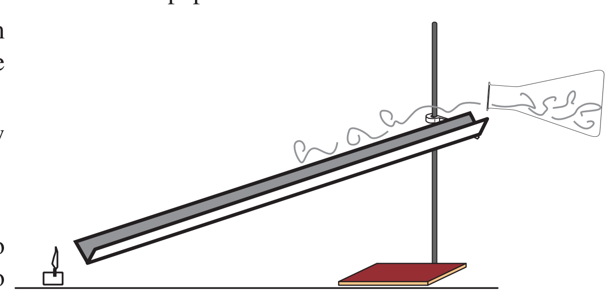

Figure 1.

Procedure

1. Have all of the students in the class put on their safety goggles.
2. Light the candle and position it so that the flame is even with the bottom of the vapor ramp.
3. Remove the stopper from the flask containing the hexane. Gradually pour the hexane vapors only down the ramp for about 3 seconds. Tip the flask slightly but ***do not allow any unevaporated liquid hexane to pour out***. Be prepared to have the fumes catch fire.
4. Nothing will happen for a few seconds—be patient. The vapors will soon ignite and then race up the ramp. *Caution:* Do not continue to pour once the vapors have ignited at the candle source. Once the flames start, remove the flask from the top end of the vapor ramp.
5. After the flames race up the trough, the demo can be repeated.

Tips

- A small, flat votive candle is ideal for this demonstration. If a taller candle is used, adjust the vapor ramp so the vapors can flow onto the top part of the candle flame and ignite.
- Hexane, hexanes, or petroleum ether (NOT ethyl ether) have a similar composition and boiling point and will work well in the demonstration. Do NOT substitute any other flammable liquids for this demonstration.
- If the ramp cannot be adjusted using a ring stand and clamp, hold the ramp with one hand using an oven glove or a fire-resistant welder's glove. Hold the ramp from beneath, open-side up. Keep fingers and gloves away from any flames.
- Shop at your local hardware store for aluminum angle brackets—we found our brackets as drop ceiling flashing. The sides of the bracket should be about 0.75–1.5 inch.
- Practice this demo beforehand to understand how long to pour the hexane vapors. The flask should not be near the trough when the flames ignite. If you are still pouring when the flames start, take the flask away from the top of the vapor ramp to prevent the fire from going back into it. (If the flame does make it back into the flask, it is OK; it will just burn there for a while at the mouth of the flask, unable to burn the entire sample due to inadequate oxygen.)

Discussion

Many organic solvents have very low boiling points and hence are highly volatile at ambient temperatures. For example, hexane has a boiling point of 68–70 °C (154–158 °F) and a vapor pressure of 150 mm Hg at 25 °C. The vapors of most organic compounds are colorless and therefore nearly impossible to see. Hexane (C_6H_{14}) has a molar mass of 86 g/mol. This gives hexane vapors a density nearly three times greater than that of air (nitrogen, 28 g/mole, and oxygen, 32 g/mol). Thus hexane vapors (and most other organic vapors) are heavier than air and will sink in air. Heavier-than-air vapors are also easy to pour.

When the hexane vapors are poured down the vapor ramp and make their way to the lit candle, all three necessary ingredients for a fire are present—air (containing oxygen), hexane fuel, and a source of ignition or heat. The vapors ignite and the resulting flames travel back up the ramp, leaving an impressive trail of fire in their wake.

What makes this an especially valuable demonstration is the safety lesson to be conveyed: *Using flammable liquids indoors can be a fire hazard even if you are nowhere near an open flame.* Indeed, as any firefighter can attest, volatile fumes can travel along the floor, even down steps, and find an ignition source, such as the pilot light of a furnace or hot water heater or an electric switch. Outdoors, ignition sources are less common, and winds generally cause flammable vapors or fumes to dissipate before they reach combustible levels.

References

Becker, R. *Twenty Demonstrations Guaranteed to Knock Your Socks Off!,* Vol. 2; Flinn Scientific: Batavia, IL, 1997, pp 59–60.

Materials for *Flaming Vapor Ramp* are available from Flinn Scientific, Inc.

Catalog No.	Description
H0046	Hexanes, 100 mL
AP6154	Flaming Vapor Ramp Demonstration Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.