Mentoring the Next Generation of Pyros

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This session features one of the members of the student science demo team at M. B. Lamar High School in Arlington, Texas. She has been an active demonstrator for the past three years and currently serves as the Safety Officer for the organization. We will be sharing her three most-favorite chemistry demonstrations: Burning Money, the Nerf Cannon, and Dynamite Soap. We will also share information about the sources of these demonstrations, tracing them back to where they were originally learned or created and developed. This way, we hope to keep the "demo genealogy" intact for these simple and entertaining demonstrations.

Burning Money

Materials Used:

Isopropyl alcohol, 70% v/v solution; water; plastic cup; flame source (lighter); US dollar bill (your own or solicit one from an audience member); tongs.

Procedure:

Prior to the demo: Make a 50% v/v solution of isopropyl alcohol by adding 70 mL of 70% isopropyl alcohol to 30 mL of water. Mix well and place in plastic cup. This solution may be stored in a sealed container and used repeatedly.

To do the demo: Either show the audience your dollar bill or ask audience members for a dollar bill. Place the dollar bill into the 50% isopropyl alcohol solution and wet the bill completely with the solution. Use tongs to lift the bill from the solution, making sure that the bill is flat when fully removed from the solution. Allow the bill to drip back into the cup for a few seconds. Move the cup away from the bill before igniting the bill. Use the lighter to ignite the bill. It will become fully engulfed in visible flames for a few seconds and then will go out. Have an audience member examine the bill and describe its condition after being "burned"—it will be observed that the bill is not hot but very wet.

What's going on here: The isopropyl alcohol is very flammable, a chemical property that remains even when diluted with water. However, only half of the liquid in the solution is isopropyl alcohol. The remaining half of the solution is water, which has a high heat capacity and absorbs the heat from the combustion. There is not enough heat from the combustion to evaporate the water, so the unburned bill ends up wet as well. The bill will air dry without damage.

Safety Precautions:

Use caution when igniting the bill—do not allow burning drips to fall into the cup with the remaining solution. Isopropyl alcohol and its solutions are flammable.

History:

This demo dates back to a chemical demonstration outreach program operated by the Dallas-Fort Worth Section of the American Chemical Society in the late 1980s. As best can be recalled, the source referenced for this demo was the very first edition of *Chemical Demonstrations* by Summerlin and Ealy. (The subsequent editions of what is now known as Volume 1 of this series were revised by the removal of a number of more energetic reactions. Lacking a more recent edition of this source, it is not known whether or not this particular demo is still in the book.)

The Nerf* Cannon

Materials Used:

Nerf* Cannon with a PVC screw-in drain plug for the attached fitting (directions below, or cannon can be purchased from Flinn Scientific); 7-inch foam ball; 10 mL ethanol; flame source (lighter or match).

**Brand names are used for product identification purposes only, and do not indicate any endorsement.*

Procedure:

Prior to the demo: Obtain a 7 inch diameter sponge ball, a 5 foot length of 4" PVC drain pipe and an end cap with a screw-in drain plug to fit snugly over one end of the pipe. Glue the end cap (don't glue the drain plug) on one end of the pipe and drill a 3/8 " hole in the side of the pipe, about 1" above the edge of the cap.

To do the demo: Pour ¾ of the ethanol into the open end of the PVC pipe. Roll the pipe around so as to coat as much of the inner surface as possible with the alcohol. Push the foam ball into the open end of the pipe. Put the remaining ethanol into the pipe through the hole and roll the pipe (keeping it horizontal) for about 1 minute. Aim the pipe above people's heads and use a flame source brought to the drilled hole to ignite the ethanol inside the pipe. The foam

ball will shoot out of the open end of the pipe with an audible "boom." If any ethanol is still burning inside the pipe after the ball is pushed out, holding the pipe vertically with the open end up will extinguish the flames.

What's going on here: Coating the inner surface of the pipe with ethanol and rolling it permits the ethanol to both vaporize and mix well with atmospheric oxygen in the pipe. When ignited, this mixture combusts rapidly according to the following reaction:

$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$ + heat

The heat produced by the reaction causes the remaining gases inside the pipe (mainly nitrogen) to increase in pressure. The increase in pressure is large enough and rapid enough to cause a mechanical failure of the gas containment at the weakest point in the container: the foam ball (which has not been glued or otherwise sealed to the pipe). The ball shoots out of the end of the pipe with a great deal of force due to the pressure differential created by the reaction. (Note: This demo can also be used to demonstrate the physics concepts of projectile motion and resonance in a closed tube.)

Safety Precautions:

The foam ball will be propelled from the pipe with considerable force and may damage objects or injure people that are within 10 feet of the end of the pipe when it is fired. It is best to aim the pipe at a distant wall before firing. Ethanol and its vapors are flammable; care should be exercised to avoid inadvertent contact with sparks or open flames.

History:

A similar demonstration was performed by Tik Liem at an NSTA Regional Conference in Fort Worth in 1994. He used a regular size foam ball and about 3 feet of 2-inch PVC pipe. This inspired the creation of a larger version, and it was originally presented by KH at ChemEd 1995. Following this meeting, Flinn Scientific included the large-scale version in *Chemistry Demonstration Aids That You Can Build!* (published in 1997). Jeff Bracken also incorporated building cannons into some of his teacher workshops. Currently, Flinn Scientific offers a completed cannon in a kit for demonstrations.

Dynamite Soap

Materials Used:

2-liter soft drink bottle (with gas volumes marked); 3 feet of plastic tubing; tanks of compressed hydrogen and compressed oxygen; reverse threaded fitting and valve for oxygen tank; bucket; water; dishwashing liquid; wash tub; a flame source (lighter or match).

Procedure:

Prior to the demo: Collect hydrogen gas by water displacement in a 2-liter soft drink bottle. Fill the bottle 2/3 full of hydrogen. Then, collect oxygen gas in the last 1/3 of the 2-liter bottle, leaving only about 1" of water in the neck of the bottle. Fill the bottle lid with dishwashing liquid and cap the bottle while it is still underwater in the displacement tank (we use a bucket). Then, gently shake the bottle so that you trap the mixture of gases in the resulting bubbles. This can be prepared up to hours in advance, but should be stored with caution, neck down, prior to use.

To do the demo: You and your partner must wear hearing protection for this demo, and warn your audience that this is by far the loudest explosion they will hear (so they should cover their ears with cupped hands). Have your partner hold their arms straight out in front of them over the wash tub with their hands up and slightly cupped. Squeeze the dynamite soap bubbles into your partner's hands. Then stand back at arm's length and ignite the bubbles with a lighter. (You and your partner need to be sure to keep your mouths closed during the explosion, unless the taste of dishwashing soap is one you enjoy!) The bubbles will ignite with a loud bang, and the water from the bubbles will prevent any injury to your partner's hands. The closer your ratio of hydrogen to oxygen to 2 to 1, the louder the detonation will be. After the demo, have your partner wash the soap off their hands, and completely empty the bottle of the gas mixture by filling it to the top with water.

What's Going On Here:

When the gases are collected at a consistent pressure, the volumes of gas and their relative number of moles are directly proportional. This produces a stoichiometric mixture of 2 parts hydrogen gas to 1 part oxygen gas that reacts to form water vapor as a product. When using a stoichiometric mixture of hydrogen and oxygen gases, the reaction is very fast. The reaction front moves through the bubbles at a speed exceeding the speed of sound, which classifies this mixture as a high explosive. (High explosives detonate while low explosives deflagrate (or burn) with a visible flame.) This means that the person holding the bubbles is holding a small sonic boom in their hands, and they will definitely feel the expanding shock wave from the reaction, as will others who are close to the detonation.

Safety Precautions:

Both presenters must wear goggles and hearing protection for this demonstration. The audience must be warned about the sound of the reaction before the mixture is detonated. Both presenters must also keep their mouths closed at detonation so that dishwashing soap does not get splattered into them. Be sure to wash off all remaining soap so that it does not irritate skin.

History:

Lee Marek is our original source for this demonstration. He used it during an appearance on *Late Night with David Letterman*, with Letterman holding the bubbles. (If you get the chance to see this particular experiment, it's hilarious!) While Lee usually estimates the relative amounts of gases and uses a smaller (20 oz.) bottle, we scaled it up to 2-liter bottles. We also measured and marked the appropriate volumes on our bottles so that we reliably get loud detonations from complete reactions.