Mini Rockets

Student Objective
The student:
- will observe and compare two gas-producing reactions
- will relate chemical concepts to observations of chemical reactions
- will infer a conclusion and evaluate methods

Key Words:
combustion
propulsion
proportion
rocketry

Time:
1 class period
Prep time: 60 minutes initial time, 30 minutes with already fabricated sparkers, generators, and calibrated rockets.

Materials
- 1.0 M Hydrochloric Acid (HCl), approx. 50 mL per demo
- 3% Hydrogen Peroxide (H_2O_2), approx. 50 mL per demo
- mossy zinc
- yeast water
- 10 mL graduated cylinder
- tap water
- piezoelectric sparking unit (instructions for construction follow)
- tape measure

For generator unit (2 required):
- vial with pop-off lid, such as empty film canisters
- nail
- petri dish half
- pipette bulb, calibrated
- hot glue gun and glue (or water-proof adhesive)

Background Information

The space shuttle uses liquid hydrogen and liquid oxygen for its three main engines. The hydrogen is the fuel and the oxygen is the oxidizer. Without either one the shuttle would not make it to outer space. Hydrogen and oxygen are two gases that react with each other in a very quick, exothermic manner. The explosiveness of this reaction is greatest when the hydrogen and oxygen are mixed in just the right proportion. Students will find combustion does not occur with hydrogen or oxygen individually. As well as showing the nature of the fuel used on the space shuttle, the student should also be able to realize the safe nature of hydrogen versus other fuel sources.

Safety

- Safety goggles and apron must be worn throughout this activity.
- Clean all chemical spills promptly. In case of a spill, use dampened paper towels to mop up the spill. Then rinse the towel in running water, wring it out until it is only damp, and put it in the trash.
- Remind students not to aim their rockets at other students.
- Monitor student use of the generators. Both gas-generating reactions release heat, thus building up pressure in the generator. (If the pressure is too great, the container could explode. Due to this explosion risk, it is necessary to use containers with lids that can pop off and ensure the reaction rates are not too fast for the size of the container. This would include not adding too much solution to the canister and not adding too much catalyst (or zinc) to the gas-generating vessels.)

Disposal

- You may want to have disposal containers for the spent solutions from the generators for use throughout the experiment (if you do this with several classes through the day.)
- The materials used to make oxygen may be washed down the sink, provided the school drains are connected to a sewer system with a treatment plant.
- The materials used to make hydrogen need to be combined. Filter to separate the zinc and rinse the zinc at least three times with water. Collect the acidic washings with the filtrate. After the rinsed zinc is dry, it may be saved for reuse. Neutralize the acid solution before flushing down the sink.
- Any other solutions generated may be flushed down the sink with water.

Procedure--Solution/Material Preparation

1. 3% hydrogen peroxide may be store-bought. It should be fresh.
2. To prepare yeast water, dissolve one tablespoon of dry yeast in 100 mL of water.
3. To make calibrated pipette bulbs:
   - cut the pipette near the graduation closest to the bulb trying to keep the cut straight
   - with a permanent marker or paint pen, divide one pipette into six equal sections
   - use this pipette as a guide to mark the other pipette.
4. To make gas generators:
   - Cut the tapered tip off a graduated pipette. This works best if the pipette is cut on the stem portion just above the tapered tip. By cutting in this location, a relatively airtight seal can be made.
   - Punch a hole in the center of a film canister lid.
   - Slip the nozzle into the hole until the flared section wedges into the hole on the inside portion of the lid.

- Repeat.

5. Decide on a launching area for the rockets and mark it appropriately.

To make your own Piezoelectric sparking units from gas grill igniters:
Materials:
- Gas grill replacement igniter, 1 per sparking unit (available at hardware stores)
- Electrical tape
- Film canister lid, 1 per sparking unit
- Hot glue gun and glue (or water-proof adhesive)
- 24-gauge speaker wire (solid, not stranded: Radio Shack #278-1509), 10 cm per sparking unit
- Wire strippers
- Scissors

Constructing the piezoelectric sparkers:
- Using scissors, split **one** end of a 10 cm length of speaker wire down the center 4-5 cm. Be careful to ensure that the insulation around each strand is not damaged.
- Strip the last 2 cm of insulation from both sides of the split portion and strip just the tip of the unsplit end.
- Cut two pieces of electrical tape long enough to wrap around the gas grill igniter.
- Place one of the stripped ends of the split speaker wire against the metal tab of the igniter and secure with electrical tape. A dot of glue from the glue gun could be used before taping to make the connection more secure, but this is optional.
- Bend the other stripped end of the wire back and push it into the tip of the igniter so that it makes contact with the electrode pole in the tip. Again, secure with electrical tape.
- Poke or melt a hole in the film canister cap and slide it over the wire so that it rests atop the ignitor.
- Test the sparker, holding it as a syringe with your thumb on the trigger button and fingers over the film canister cap. A "tiny" spark needs to flash across the end of the wire. If you can't see the spark, try to reposition the sparker or try it in the dark. If there is no spark, there could be a short or one of the wires has come loose. Check to make sure the wire in the tip of the igniter is still in place, and that the wire is still on the igniter's metal tab.
- To avoid shocks, go around the entire ignitor body with a wrapping of electrical tape.
- Secure the film canister lid in place with a drop of glue from the glue gun on the top where the wire protrudes from it.
- Bend the last 1 cm of the tip of the speaker wire up at a 90 degree angle to create a launch pad for the pipette bulb to rest over.

Alternative method of making the piezoelectric sparkers from fireplace lighters:
Materials**:**
- piezoelectric butane charcoal/ fireplace lighter
- vinyl electric tape

- film canister cap, 1 per sparking unit
- hot glue gun and glue (or water-proof adhesive)
- 24 AWG speaker hook-up wire (solid , not stranded: Radio Shack #278-1509), 10 cm
- wire strippers

Constructing the piezoelectric sparker:

- using scissors, split one end of a 10 cm length of speaker wire down the center for a distance of 3-4 cm.
- strip the last 2 cm of insulation from both sides of the split portion
- using a nail, push the nail through the center of the film canister lid. It should not take any special effort to push through the nail
- slide the wire through the canister lid so the bottom of the lid will face away from the sparker and the split portion of wire will face towards the sparker. The canister lid acts as both a splash guard and a launch support pad
- secure the lid in place about 4 cm from the unsplit end of the wire with hot glue or other waterproof adhesive
- slide one of the stripped portions into the small hole in the nozzle of the lighter until the insulation is against the nozzle. (The Scripto Aim 'n Flame II and the Bic Sure Start were both used successfully. If the Bic Sure Start is used, the tiny spring in the nozzle needs to be removed so the wire will fit.) lay the other stripped portion along the outside of the lighter and secure it in place with a few wrappings of electrical tape
- test the hot glue seal and the sparker. The seal needs to be watertight and a "tiny" spark needs to flash across the end of the wire. If you can't see the spark, try to reposition the sparker or try it in the dark. If there is no spark, there could be a short. Check to make sure the only wire touching the metal part of the lighter is the taped portion.

Procedure–during experiment

1. Explain to the students that NASA uses a combination of liquid hydrogen and liquid oxygen to launch their rockets. The hydrogen is the fuel and the oxygen is the oxidizer (which allows the fuel to burn). Tell the students that as a group they will decide which fuel mixture works the best to launch the mini rocket.
2. Write the testing matrix on the board:

Parts (amount) H_2							
Parts O_2							
Rating							

3. Pour the chemicals in the generators. Use 2-3 pieces of mossy zinc in the hydrogen generator (depending on their size). You will fill this generator with HCl to about 10 cm from the top. If there is too much solution added, the generator may explode. If enough solution is not added, the bulb may have more air than hydrogen or oxygen resulting in incorrect data and/or the students might be constantly refilling the generators.
4. In the oxygen generator, fill with hydrogen peroxide to about 10 cm from the top. Add 10-20 drops of yeast water.
5. Put the lids on the generators and place them in the petri dishes of water.
6. The students could decide on their own test parameter (i.e. distance traveled, loudness of pop, brightness of flash) and its measurement (for some parameters this will of course be subjective).
7. Have one student record the results on the board. The other students should tell them what to write.
8. Since the bulbs are graduated in sixths, the proportions can be measured using parts of hydrogen to parts of oxygen from zero parts hydrogen to six parts hydrogen. Call on a student before each trial to say which proportion to try on this trial.
9. After each shot, allow a student to run up and call out how far the rocket traveled.
10. Note: If either generator reaction slows down so that it takes more than one minute to fill the bulb with gas, fresh solution should be put in the micro-generators.
11. After the experiment is completed, lead a discussion with the class. Questions you may want to ask include:
    - What are the end products of this reaction? *(heat, light, water, sound, thrust)*
    - What proportion worked the best for the combustion reaction? *(2:4 or 1:2)* What molecule has these proportions of hydrogen and oxygen? *(water–H_2O)*
    - Why is the pipette propelled forward? *(the reaction causes pressure to be forced out of the end of the pipette, propelling it forward)*
    - What proportion of fuels do you think that NASA uses in the Space Shuttle *(1 part oxygen to 2 parts hydrogen)*

Related Research

1. Launch a commercially made model hydrogen rocket. Discuss the similarities and differences with the mini rockets and the two fuel mixtures.
2. Research how NASA uses combustible hydrogen fuel in its space program

Mini Rockets

			.1	.2	.3	.4	.5	.6
Nature of Matter	Standard 1	SC.A.1.2-					X	
	Standard 2	SC.A.2.2-						
Energy	Standard 1	SC.B.1.2-		X		X	X	
	Standard 2	SC.B.2.2-						
Force and Motion	Standard 1	SC.C.1.2-	X					
	Standard 2	SC.C.2.2-		X	X			
Nature of Science	Standard 1	SC.H.1.2-	X	X				
	Standard 2	SC.H.2.2-						
	Standard 3	SC.H.3.2-		X				

Benchmark SC.A.1.2.5 - The student knows that materials made by chemically combining two or more substances may have properties that differ from the original materials.
Grade Level Expectations
The student:
Fifth
- knows the difference between physical and chemical changes.

Benchmark SC.A.1.2.2 - The student recognizes various forms of energy
Grade Level Expectations
The student:
Third
- knows different forms of energy.

Benchmark SC.A.1.2.4 - The student knows the many ways in which energy can be transformed from one type to another.
Grade Level Expectations
The student:
Fourth
- knows ways that energy can be transformed.

Benchmark SC.B.1.2.5 - The student knows that various forms of energy can be measured in ways that make it possible to determine the amount of energy that is transformed.
Grade Level Expectations
The student:
Third
- uses a variety of tools to measure the amount of energy

Fourth
- extends and refines use of a variety of tools to measure the amount of energy

Fifth
- extends and refines use of a variety of tools to measure the amount of energy.

Benchmark SC.C.1.2.1 - The student understands that the motion of an object can be described and measured.
Grade Level Expectations
The student:
Third
- describes the motion of various objects

Fifth
- uses scientific tools to measure speed, distance, and direction of an object.

Benchmark SC.C.2.2.2 - The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.
Grade Level Expectations
The student:
Third
- knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

Benchmark SC.C.2.2.3 - The student knows that the more massive an object is, the less effect a given force has.
Grade Level Expectations
The student:
Fifth
- knows the relationship between the strength of a force and its effect on an object.

Benchmark SC.H.1.2.1 - The student knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.
Grade Level Expectations
The student:
Third
- knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments

Benchmark SC.H.1.2.2 - The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

Grade Level Expectations

The student:

Third

- uses various kinds of instruments to collect and analyze information

Fourth

- uses metric tools to measure, record, and interpret data

Benchmark SC.H.3.2.2 - The student knows that data are collected and interpreted in order to explain an event or concept.

Grade Level Expectations

The student:

Third

- knows that data are collected and interpreted in order to explain an event or concept
- understands that scientific information can be presented in several ways

Fourth

- constructs and analyzes graphs, tables, maps, and charts to organize, examine, and evaluate information.

Mini Rockets

combustion - a chemical change accompanied by the production of heat and light

propulsion - movement of a body produced by the forward forces of the reaction resulting from the rearward discharge of a fluid

proportion - a relationship between quantities such that if one varies then another varies in a manner dependent on the first

rocketry - the branch of engineering science that studies rocket design and operation