DIAPER GEL TESTING

BIG IDEA

Play the role of a chemist working for a diaper company. Your task is to compare different diaper designs and use your findings to determine which is most effective.

READY...

Gather materials:

- 2 bowls
- cup
- disposable diapers (2 different kinds)
- notepaper
- pencil
- plastic spoon
- scissors
- 2 sealable plastic bags
- water

SET...

Fill the cup with water.

GO!

1. Label each diaper "1" or "2," and then do the same for the sealable bags and bowls.
2. Observe the design of each diaper. What material(s) is it made of? What shape is it? How heavy is it relative to the other diaper? Does it have any scent or pattern? Record your observations on your notepaper.
3. Cut open the diapers along the seam and scoop out the tiny crystals (called sodium polyacrylate) into the corresponding bowls. As you do this, use the spoon to measure the quantity of sodium polyacrylate that each diaper contains and record this information on your notepaper.

Cutting open a diaper

4. Scoop 1 spoonful of crystals from each bowl and add it to the corresponding sealable bag. Since some diapers contain more crystals than others, this lets us see how much water each diaper can absorb for every spoonful of crystals.
5. Carry out these steps for each bag of crystals:
   a. Using your spoon, slowly add water into each bag—until the sodium polyacrylate no longer absorbs it.
   b. Record the amount of spoonfuls of water added on your notepaper.

Extracting polymer crystals

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6. Consider the advantages and disadvantages of each diaper design:

- Which design seems most comfortable?
- Which design absorbs the most water per spoonful of sodium polyacrylate? (Some diapers may absorb better than others because manufacturers use a mixture of several polymers, not just sodium polyacrylate.)
- Which design absorbs the most water in total (found by multiplying the volume of sodium polyacrylate by the absorption per teaspoon)?

Chemical safety and disposal: Sodium polyacrylate is nontoxic, though it can irritate the eyes. It should not be disposed of down the drain! Instead, place the gel and any unused crystals in the garbage.

WHY IS THIS SCIENCE?

The white crystals in diapers are made of a polymer called sodium polyacrylate, which is hydrophilic, meaning "water-loving." Polymers are groups of chemicals made of long chains of molecules. When sodium polyacrylate meets water, it bonds with the water molecules and holds onto them tightly—so the water can no longer act like a liquid.

This is very different from how a towel works, since in that case water molecules just hide in small crevices. When you squeeze a towel, the water is forced back out, but no amount of squeezing will make the sodium polyacrylate let go of its water molecules!

Such a polymer, which can absorb lots of water, has many uses. For example, sodium polyacrylate is often used in agriculture as an additive to potting soil. The polymer soaks up large quantities of water when there is plenty of rain, then releases it when the soil is in danger of drying out. Paints containing sodium polyacrylate are sometimes used to coat moisture-sensitive equipment. That way, if there is a lot of humidity in the air, the polymer absorbs water droplets before they can damage the equipment.

WITH THANKS AND FOR MORE INFORMATION, VISIT:

This activity has been adapted from "Exploring a Hydrogel," *Celebrating Chemistry*, American Chemical Society (https://communities.acs.org/docs/DOC-56395) and "Diaper Dissection," *Experiencing Chemistry*, OMSI (https://omsi.edu/sites/all/FTP/files/chemistry/Side_Displays/U5DiaperDissection_OpGuide.pdf).

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BATH BOMB

BIG IDEA

Make a bath bomb to learn how an acid and a base can create a fizzy, fun chemical reaction!

READY...

Gather materials:

- baking soda
- bowl
- citric acid
- essential oil (optional)
- food coloring (optional)
- paper towel
- plastic wrap
- plastic mold
- vegetable oil

SET...

No setup needed!

GO!

1. Use a paper towel to rub a small amount of vegetable oil in the bottom of the mold to keep the bath bomb from sticking.
2. Add these ingredients to your bowl. Use a spoon to stir the mixture after each ingredient is added:
   - baking soda
   - citric acid
   - vegetable oil *(Add small amounts of oil until the texture is like wet sand. This should make the mixture stick together.)*
   - optional: 3-4 drops of food coloring and essential oil. Massage the color and oil into the mixture.
3. Once the color and oil have been massaged through the mixture, press part of the mixture into the mold to shape the bath bomb.
4. Let the bath bomb dry overnight so it won't fall apart.
5. Wrap the bath bomb in plastic wrap to seal it from air until you are ready to use it, as humidity will ruin it.

Chemical safety: All the ingredients are nontoxic and can be disposed of in the garbage or down the drain. If citric acid comes into contact with eyes, flush with water.

WHY IS THIS SCIENCE?

Bath bombs contain two kinds of powders: one that becomes an acid when dissolved in water, and one that becomes a base. Acids and bases are chemically opposite. Because of this, they neutralize (cancel) each other when mixed.

Acids are chemical compounds that have a sour taste and can cause skin to burn or tingle if touched. Examples

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of things that contain acids are vinegar, lemon juice, grapefruit juice, and carbonated beverages like club soda. Bases are chemical compounds that have a bitter taste and feel slippery to the touch. Instant coffee and baker's chocolate taste bitter. Other common bases are ammonia, baking soda, and antacids. Some acids and bases are dangerous; they can be poisonous or can burn a person's skin.

In this activity, the bath bomb is made of citric acid (acid) and baking soda (base). When the two mix, they neutralize each other and create the fizzing reaction! The reaction produces a new substance called sodium citrate, plus water and carbon dioxide (that is the gas forming the bubbles). This is the equation:

$$C_6H_8O_7 + 3NaHCO_3 \rightarrow Na_3C_6H_5O_7 + 3H_2O + 3CO_2$$

citric acid + baking soda → sodium citrate + water + carbon dioxide

Since we end up with substances different from what we started with, this is a chemical change.

Citric acid is a naturally occurring compound found in lemons and other citrus fruit (hence the name). It is often used in food products, either as a preservative or to provide a sour punch. Powdered lemonade usually contains citric acid, so you can get a great fizzing reaction by mixing lemonade powder and baking soda in water.

Baking soda is a common baking ingredient. It is often used to make dough light and fluffy (as in cookies, biscuits, pancakes, and some breads). This works because the baking soda reacts with acids in the dough, making tiny bubbles of carbon dioxide.

WITH THANKS AND FOR MORE INFORMATION, VISIT:

This activity has been adapted from "How to Make Homemade Fizzy Bath Bombs," Anne Helmenstine, *Science Notes* (https://sciencenotes.org/how-to-make-homemade-fizzy-bath-bombs/).

BOMBARDIER BEETLE

BIG IDEA

Create a working model of the bombardier beetle's chemical defense mechanism—and consider how this incredible adaptation found in the natural world has inspired chemists to develop useful products.

READY...

Gather materials:

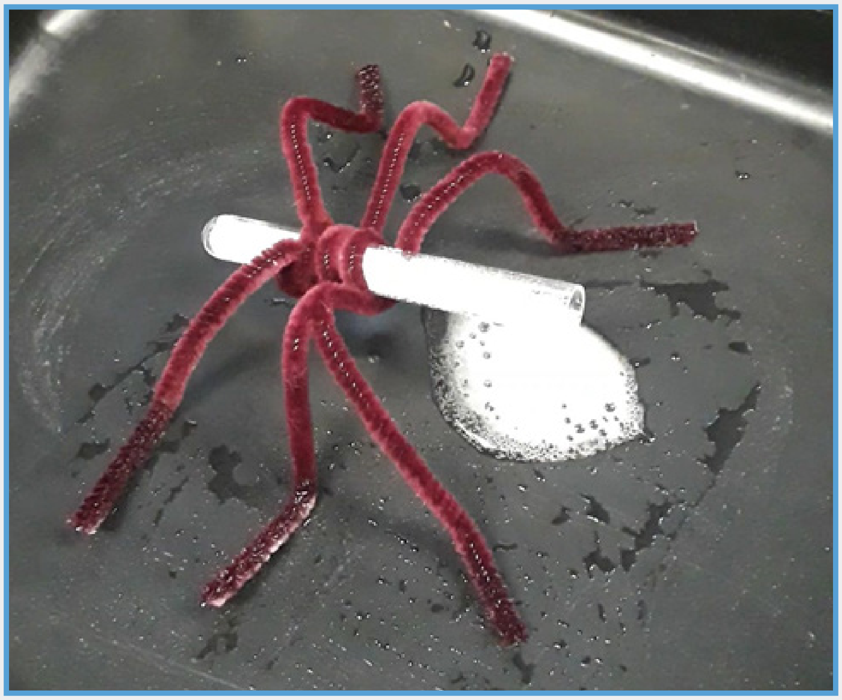
- 3, 6-inch pipe cleaners
- baking soda
- bombardier beetle photos
- colored markers
- disposable plastic pipette (optional)
- glue (optional)
- googly eyes (optional)
- paper
- plastic test tube (or aluminum foil rolled into a tube)
- plate (optional)
- pompoms (optional)
- scissors (optional)
- vinegar

SET...

Pour a small amount of vinegar into the cup. You will need 1 mL (0.0338 oz.) per bombardier beetle "explosion." You could pour the vinegar into the tube instead of using a pipette.

GO!

1. Decorate the test tube (the beetle's body) however you wish. You can color it with markers and glue on pompoms, googly eyes, or other decorations.
2. Once the glue has dried, wrap the pipe cleaners (the beetle's legs and feet) around the test tube.
3. When the crafting is done, place the beetle in the sink or on a plate with the test tube opening angled upward.
4. Use a rolled-up piece of paper to guide the baking soda into the test tube.
5. Use the disposable pipette to add 1 mL (20 drops) of vinegar to your beetle and observe what happens. (A stream of foamy bubbles should eject from the beetle's abdomen! Just like a real bombardier beetle.)
6. You may add vinegar more than once if you want to.



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WHY IS THIS SCIENCE?

Many of the inventions that make our lives easier existed in nature long before we created them—whether scientists realized it or not. In fact, the natural world is so sophisticated that scientists have used it for inspiration for at least 3,000 years! When scientists intentionally study plants and animals with the aim of reproducing some trait—whether that is a structure, a mechanism, or a substance—it is called biomimicry. The word "biomimicry" has two important components: bio means life (as in biology, the study of life), and mimicry means imitation or copying.

The first step of solving a problem through biomimicry is to translate what you need out of a design into biological terms. For instance, what if you wanted to design a fire extinguisher with a longer range? Where in nature have organisms evolved to deal with a similar problem? Bombardier beetles might not deal with quenching a flaming stovetop, but they have evolved to squirt a heated, explosive stream of venom at predators. Once discovered, the next challenge is to take the lesson from nature and apply it back to your design. In the case of the bombardier beetle, researchers studied the insect's use of a high-pressure "combustion chamber" in its abdomen. Designers have begun applying this discovery to existing spray technology.

Bombardier beetles are a group of 500 species of small, carnivorous beetles found worldwide (except for Antarctica—but including North Carolina!). Their name comes from their unique defense mechanism. When threatened, bombardier beetles mix two chemicals in their abdomen, causing a violent exothermic reaction that releases heat. The beetle takes aim, and a noxious, boiling liquid literally explodes onto the face of the beetle's attacker. These two chemicals are hydrogen peroxide and hydroquinone. Since hydroquinone is carcinogenic and genotoxic (and the resulting mixture stinks), this activity uses vinegar and baking soda to create the beetle.

WITH THANKS AND FOR MORE INFORMATION, VISIT:

Information about biomimicry in this activity was adapted from "How Biomimicry Works," *How Stuff Works* (https://science.howstuffworks.com/life/evolution/biomimicry2.htm).

Photograph by Morehead Planetarium and Science Center.

BOMBARDIER BEETLES

Orange County, North Carolina

Photo by Patrick Coin (CC BY-SA 2.5)

Gorongosa National Park, Mozambique

Photo by Judy Gallagher (CC BY 2.0)

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WHAT IS (IN) INK?

BIG IDEA

Use a scientific technique called chromatography to examine the inks in different types of markers.

READY...

Gather materials:

- 2 chromatography paper strips
- cup
- non-permanent markers (2 different types or colors)
- pencil
- plate
- Popsicle stick
- tape and water

SET...

Pour approximately a ¼-inch of water into the cup.

GO!

1. Draw a line about one inch from the bottom of each chromatography paper strip using a pencil.
2. Use a marker to make a small, dark dot in the middle of the pencil line on one of your chromatography paper strips. Darker dots will have more ink and can show more visible results. Very light dots will have less visible results.
3. Use a different marker to make a small, dark dot in the middle of the pencil line on your other chromatography paper strip.
4. Use your pencil to label the squared end of each strip with the name/color/source of the ink being tested.
5. Use tape to secure the squared end of a strip to the left side of the long side of a Popsicle stick. Tape the remaining strip to the right side of the Popsicle stick.
6. Lay the Popsicle stick on the top of the plastic cup, so that the end of each strip dangles in the liquid below. The ink sample should not be submerged in the liquid. Add more water if it doesn't touch the tip of each strip.
7. Allow 5-10 minutes for the liquid to migrate up the paper. The inks should now separate along the paper.
8. Remove the strips of paper from the Popsicle stick and lay them flat on a plate so they can be observed and dry out.
9. The ink patterns on the paper are “chromatograms.” Compare your chromatograms. Do you notice any differences?

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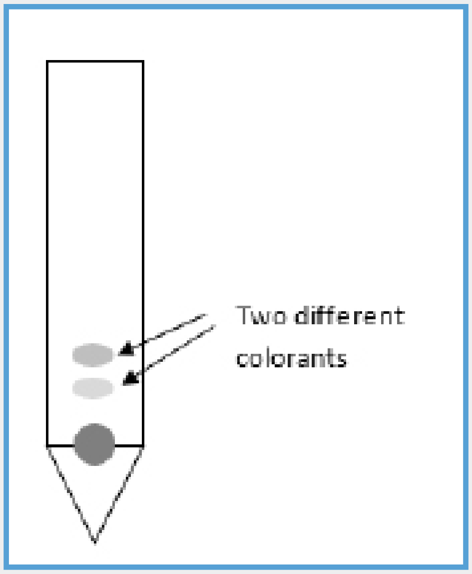
WHY IS THIS SCIENCE?

Scientists often use a method called chromatography to separate a mixture into the chemicals of which it is composed. A mixture is a collection of different chemicals that share space but are still distinct from each other. Examples of mixtures:

- Air: a mixture of different gases, including nitrogen and oxygen.
- Whipped cream: a mixture of air in liquid cream.
- Trail mix: a mixture of different solid snacks.



Ink is a mixture of two main components. Colorant—the visible part of the ink that gives it color—is the component that moved up along the paper. Solvent is the liquid portion. Many inks have either water or alcohol as a solvent, which means that either water or alcohol can dissolve the ink. (Most inks also have additional resins and additives that give the ink other properties, such as quicker drying, longer-lasting color, permanency, etc.)

The inks used in this chromatography experiment are mixtures of several different dyes. The colored dyes move across the chromatography paper with different speeds depending on their molecular properties. When the water comes in contact with the dye on the paper, certain molecules in the dye are attracted by the water (H_2O) molecules and, therefore, move more quickly than other molecules in the dye. For this reason, the colors in the ink mixture separate and appear as bands of color on the chromatography paper.

Chromatography methods are used by scientists working in a numbers of careers. These are some examples:

- Forensic investigators: Crime scenes are often investigated with chromatography. For example, a form of chromatography can be used to analyze blood or other DNA evidence left at a crime scene, or to identify unknown substances that the investigators find there.
- Pharmaceutical scientists: In order to develop medicines that are safe for us, it is very important to know what is in these mixtures.
- Food safety officials: Chromatography is used to make sure pesticides and other harmful items are not in water and other drinks that are given to the public.

Photograph and illustration by Morehead Planetarium and Science Center.