LIGERBOTS ▪ ***FIRST*® Robotics Team 2877**

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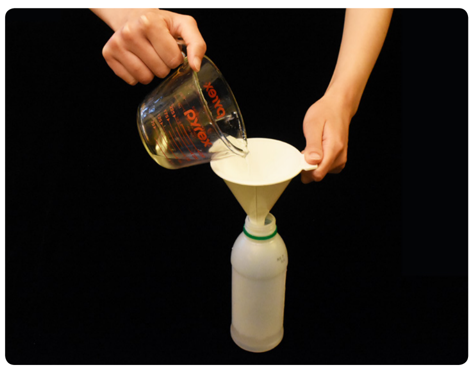
Elephant Toothpaste

Mix up some colorful chemistry!

Materials

- *Plastic soda or water bottle*
- *½ cup (118 ml) 20-volume hydrogen peroxide liquid (6% hydrogen peroxide, found in beauty supply stores. Don't touch it. For a safer option, use the 3% hydrogen peroxide in pharmacies, but the reaction will be smaller).*
- *1 Tablespoon (15 ml) dry yeast*
- *3 Tablespoons (15 ml) warm water*
- *1 tablespoon (15 ml) liquid dishwashing soap*
- *Food coloring*
- *1-cup measuring cup*
- *Funnel*
- *Safety goggles*
- *One long stick of some sort (chopstick, popsicle stick)*
- *Tarp or tray to protect table*

Materials



1. Use a funnel to pour ½ cup (118 ml) hydrogen peroxide into the bottle.

2. Add 10 drops of food coloring and 1 tablespoon (15 ml) of dish soap.

3. Gently mix the hydrogen peroxide and liquid dish soap with the stick.

4. In a separate cup, combine the warm water and yeast and mix for 30 seconds.

5. Pour the yeast-water mixture into the bottle and feast your eyes on the chemical reaction!

The Science Behind Elephant Toothpaste

Yeast makes the reaction happen faster: catalysts

Elephant toothpaste foam is made up of tiny oxygen bubbles that form when hydrogen peroxide breaks down into water and oxygen. Hydrogen peroxide will naturally break down this way, but very slowly. So, we add yeast to make the chemical reaction go faster and the experiment more exciting. The yeast contains a biological catalyst, a substance that increases the rate of a reaction without being changed itself.

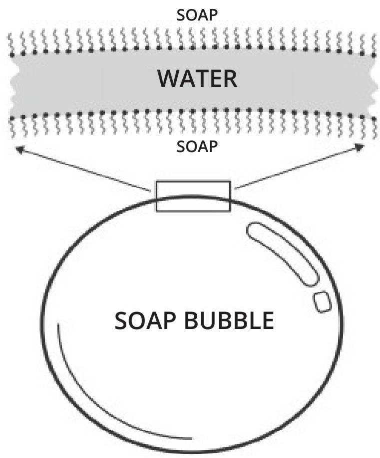
Bubbles want to be spheres

Bubbles tend to be spherical because the surface tension in the bubble's soap film forces the bubble to become the most compact shape it can be, given the volume of air inside. A sphere is the most compact shape possible. Being spherical equalizes the surface tension over the whole bubble, which makes the bubble stronger. In foams, such as elephant toothpaste, thousands of bubbles rest against the surface of adjacent bubbles and are deformed into less spherical shapes, but they still keep their surfaces as small as possible. Bubbles eventually pop either because they merge with other bubbles or touch surfaces that can puncture their soap film wall, or because the water in them evaporates into the air, damaging the wall.

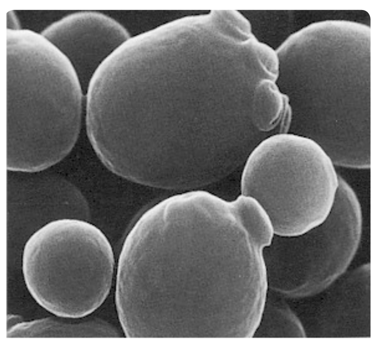
Elephant toothpaste is warm: exothermic reactions

During the reaction, the bottle will be warm to the touch because the reaction is exothermic, meaning it releases energy in the form of heat. (Chemical reactions that are cold when you touch them are called endothermic reactions, because they store energy rather than releasing it. Melting ice and photosynthesis are examples.)

A group of soap bubbles deforming each other as they touch. Image: pixabay.com



Surface tension: a soap film "sandwich." Image: scienceworld.ca



Budding yeast cells. Image: microbiologyclass.com

Soap keeps the bubbles from popping: surface tension

The oxygen bubbles in elephant toothpaste would pop quickly if they were made of just water because the surface tension of water is high: the molecules in the surface layer of the water are attracted to the molecules farther down. The wall of a plain water bubble is too thin to fight this attraction, and the bubble quickly collapses and bursts. Adding soap creates a "soap film sandwich" at the outer surface of the bubble, with soap molecule "bread" on the outside and a water molecule "filling" between the layers of soap. Spreading out the water molecules in the "filling" lowers their surface tension to about a third of what it was. The bubble can last longer because the surface film of the bubble is now strong enough to overcome the water molecules' (weakened) attraction to each other.

A chemical equation shows how elephant toothpaste is formed

A diagram called a chemical equation shows how elephant toothpaste is formed. The equation shows what you will end up with when you combine different chemical ingredients, just like a recipe from your kitchen. It is called an equation because the number of atoms before a reaction is always equal to the number of atoms after the reaction. The chemical equation for elephant toothpaste is in the box below.

We can use ball-and-stick models to show the elements in the substance that will be affected by the chemical reaction. On the left are the starting materials, the "reactants," and on the right are what we get after the reaction, the "products." An arrow shows what products the reactants will become.