

Brushing Up on Chemistry

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In this Activity, students make their own toothpaste and use various tests to compare its properties with those of commercial toothpaste.

Background

Commercial toothpastes contain ingredients that can typically be divided into nine categories: *fluoride* (sodium fluoride or sodium monofluorophosphate) makes tooth enamel resistant to acids; *abrasives* (calcium phosphate or calcium carbonate) remove stains and plaque; *detergents* (sodium lauryl sulfate) create a foam to keep the toothpaste in the mouth; *humectants* (glycerin or water) give toothpaste texture and allow the mouth to retain moisture; *thickener* (carrageenan or cellulose gum) adds to the texture; *preservatives* (sodium benzoate) prevent the growth of harmful microorganisms in the toothpaste; *flavoring agents* improve the taste and mask the taste of the detergents; *sweetener* (saccharin) improves the taste; and *coloring agents* (titanium dioxide to make it white or artificial dyes to make it red/blue/green, etc.) give the toothpaste an appealing color (1). Many other items, some of them listed in the introduction on the Student Activity, have been used to clean teeth in the past (2).

Integrating the Activity into Your Curriculum

This Activity is designed for use with National Chemistry Week 2002. The 2002 theme is “Chemistry Keeps Us Clean”. The Activity allows students to discover more about a cleaning product they use every day.

About the Activity

Many recipes for homemade toothpaste similar to the one used in this Activity are available. Most use the same ingredients used in this Activity. An online example with scientific tests similar to this Activity is cited below (3). Most of the materials required are available at grocery and drug stores. Only white eggs should be used. It is suggested that students be provided with hard-boiled eggs, but students could boil their own eggs in the laboratory. This may require that the Activity be spread over two days. The food coloring on the eggs is not removed by rinsing or brushing with water alone, but is removed by both commercial and homemade toothpastes. If desired, you can also stain eggs with tea, coffee, fruit drinks, etc. If a difference in cleaning is noted, it is usually that more color is removed by the homemade toothpaste than the commercial toothpaste.

Areas for discussion include the differences between an eggshell and tooth enamel, the use of cleaning or whitening agents, and the facts that a homemade toothpaste costs less, does not contain fluoride, and is more abrasive (which might damage tooth enamel).

Students should not use the homemade toothpaste or eat hard-boiled eggs that have been in the laboratory or in contact with laboratory equipment.

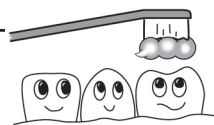
Answers to Questions

1. See background section above. In homemade toothpaste, baking soda and salt are abrasives, glycerin is a humectant. Fluoride, detergents, thickeners, preservatives, flavoring, coloring, and sweeteners are not included.
2. Homemade toothpaste is more abrasive. Abrasives remove stains and plaque but can also damage tooth enamel.
3. Water and commercial toothpaste are approximately neutral; homemade toothpaste is slightly basic. The more basic substance is useful because it neutralizes acids that cause cavities.
4. Both remove color that brushing with water alone did not. The homemade toothpaste may remove color more easily because it is more abrasive.
5. Fluoride prevents cavities because it is incorporated into tooth enamel making it more resistant to attack by acid. Fluoride compounds are toxic and toothpastes containing fluoride should not be swallowed, especially by young children (see label warnings). Brushing with homemade toothpaste would help prevent cavities by removing food particles and plaque, but the abrasive ingredients might also damage tooth enamel.
6. A whitening toothpaste could be made by adding more abrasives or a bleaching agent such as hydrogen peroxide. Stained egg shell could be brushed with or soaked in a new formula. Attempting to remove tea or coffee stains would be a particularly interesting experiment.

References (accessed August 2002)

1. Dental Zone Toothpaste—What's In It?; <http://www.saveyoursmile.com/toothpaste/toothpaste-c.html>
2. The History of Toothpaste; <http://www.edoc.co.za/dhw/history/toothpaste.html>
3. Toothpaste Testing; <http://collections.ic.gc.ca/science/english/chem/projects/chemical.html>





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Would you like to have burned egg shells on your teeth? Powdered ashes of oxen hooves? Pumice? These were ingredients in toothpastes thousands of years ago (1). Even though a tube of toothpaste typically lists only the active ingredient, sodium fluoride or sodium monofluorophosphate, commercial toothpastes today contain many more ingredients, including abrasives, detergents, humectants, thickeners, preservatives, flavoring agents, sweeteners, and coloring agents. In this Activity, you will make your own toothpaste and compare it to commercial toothpaste by testing its ability to remove colored stains from egg shells. You can color eggs one day, then make and test your toothpaste on the following day.

Try This

You will need: hard-boiled egg, boiling water, food coloring, vinegar, plastic cup, glass, measuring spoons and cups, spoon, paper towel, baking soda, salt, glycerin, dropper, commercial toothpaste, toothbrush, tap water, pH paper, black permanent marker.

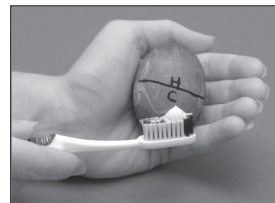
Stain the Egg

1. Pour about 0.5 cup (120 mL) of boiling water into a glass. Stir in 1 teaspoon (5 mL) of vinegar and 20 drops of food coloring (red or blue recommended).
2. Immerse a hard-boiled egg in the food coloring solution until it is stained with color (at least 5 minutes).
3. Remove the egg from the food coloring solution and place it on a paper towel to dry. Store the stained egg in a refrigerator overnight if you will not be continuing the Activity until tomorrow. Otherwise, go on to step 4.

Make and Test Toothpaste

4. Measure two teaspoons (10 mL) of baking soda and a quarter teaspoon (1.25 mL) of salt into a plastic cup. Stir until well mixed.
5. Add three-quarters of a teaspoon (3.75 mL) of glycerin to the baking soda/salt mixture. Stir it as thoroughly as possible. The mixture will be thick. Add water with a dropper while stirring until the mixture has about the same consistency as commercial toothpaste.
6. Rinse the colored egg with water and scrub it with a toothbrush. What happens to the color? Record the results.
7. With a black permanent marker, draw a line on the egg shell, dividing its surface in half. Label one side **C**, for commercial toothpaste, and the other side **H**, for homemade toothpaste.
8. Place a pea-sized amount of commercial toothpaste on the toothbrush, then brush side **C** of the stained egg for five strokes (one stroke equals one complete back-and-forth motion). Rinse the egg and toothbrush thoroughly with water. Then, place a pea-sized amount of homemade toothpaste on the toothbrush and brush side **H** for five strokes. Rinse the egg and toothbrush with water again. Record the results.
9. Measure the pH of water, the commercial toothpaste, and the homemade toothpaste using pH paper. Record your observations.
10. Compare the abrasiveness (scratchiness) of the homemade and commercial toothpastes by rubbing a pea-sized amount of each between your fingers, being sure to rinse thoroughly with water between samples. Record your observations.

Be Safe! Do not taste your homemade toothpaste or use it to clean your teeth. Never taste or eat anything in the chemistry lab or anything that has been in contact with lab equipment.



Questions



1. Research the nine categories of ingredients in toothpastes listed in the introduction. Give an example of each and explain its function. What is the purpose of each ingredient in your homemade toothpaste? What categories of ingredients are missing from the homemade toothpaste?
2. Which toothpaste felt more abrasive to you in the touch test in step 10? Why is an abrasive useful in cleaning? Can an abrasive cause any problems in cleaning teeth?
3. Compare the pH values of tap water, homemade toothpaste, and commercial toothpaste. How could pH affect the cleaning ability of toothpaste?
4. How do plain water, homemade toothpaste, and commercial toothpaste compare in cleaning ability in steps 6 and 8?
5. How does fluoride help to prevent cavities? Does it pose any risks to users? Would your homemade toothpaste help to prevent cavities? Does it pose any risks to users?
6. If you wanted to make a "whitening" toothpaste, what ingredient could you add to your mixture? Design an experiment to test your new toothpaste. Be sure to get your instructor's approval before doing any experiments.

Information from the World Wide Web (accessed August 2002)

1. Everything You Always Wanted to Know about Toothpaste; <http://www.saveyoursmile.com/toothpaste/toothpaste-a.html>