

SUMMER INSTITUTE FOR ENGINEERING AND TECHNOLOGY EDUCATION

MATERIALS ENGINEERING - TEACHER MODULE 7

MAKING A SUPER BALL

NOTE: This Module is taken from “Activity 26” of *Chemical Activities: Teacher Edition*, by Borgford and Summerlin. American Chemical Society, 1988.

INTRODUCTION

Two common liquids are mixed, and the reaction makes a solid that has the properties of rubber. The solid is a polymer. Chemists identify polymers as long chains in which molecules have linked up and twisted around each other, much like the paper chains people make for their Christmas trees. Nylon, polyethylene, wood (cellulose), proteins, and most plastics and rubbers are all polymers of particular molecules.

SCIENCE PROCESS SKILLS

- Identifying
- Measuring
- Observing
- Predicting
- Experimenting
- Collecting and interpreting data
- Analyzing data

AAAS SCIENCE BENCHMARKS

- 1A The Scientific World View
- 1B Scientific Inquiry
- 4D Structure of Matter
- 4E Energy Transformations
- 12 Manipulation and Observation
- 12E Critical Response Skills
- 5E Flow of Energy and Matter

SCIENCE EDUCATION CONTENT STANDARDS (NRC)

Grades 5-8

- Design and conduct a scientific investigation
- Use appropriate tools, techniques, and analyze data
- Construct explanations and models using evidence
- Properties of matter
- Particulate model of matter

Grades 9-12

- Identify the questions and use concepts to guide scientific investigations
- Construct and revise scientific explanations and models

- Using logic and evidence
- Recognize and analyze alternative explanations and models
- Communicate and defend a scientific argument
- Interactions of energy and matter
- Atomic structure of matter

STATE SCIENCE CURRICULUM FRAMEWORKS

Grades 5-8: 1.1.7,1.1.10,1.1.11, 1.1.12, 1.1.13, 1.1.14, 1.1.15, 1.1.16, 3.1.15, 3.1.17, 3.1.19

Grades 9-12: 1.1.20, 1.1.21, 1.1.22, 1.1.26, 1.1.27, 3.1.33, 3.1.37

MATERIALS

1. Sodium silicate (water glass) solution, 20 mL.
2. Ethyl alcohol, 5-10 mL.
3. Small paper cup for each solution.
4. Stirring stick.
5. Paper towels.

PROCEDURE

SAFETY NOTE: Wear safety goggles and plastic disposable gloves.

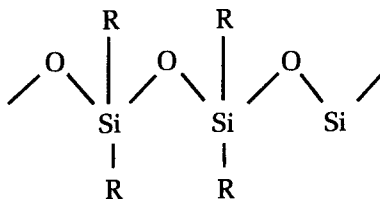
1. Measure 20 mL of sodium silicate solution and pour it into a small paper cup. Avoid contact with your skin.
2. Place 5 mL of ethyl alcohol in another paper cup. Alcohol is flammable. Extinguish all flames in the room.
3. Add the alcohol to the sodium silicate solution.
4. Using a circular motion, stir with the stick until the substance formed is solid.
5. Place the polymer in the palm of your hand and gently press with the palm of the other hand until a spherical ball that no longer crumbles is formed. Be patient. Discover a technique! Moisten the ball occasionally by holding it in a small stream of water from the faucet.
6. Bounce your ball!
7. Investigate as many property differences as you can between the two liquids and the solid polymer bouncy ball. Check the acid-base nature of each of the substances, as well as solubility in water and density.
8. Store the ball in a small plastic bag. If it crumbles, it can be re-formed.

REACTION

Silicon is a very interesting type of atom. Find its position on the periodic table of the elements. Like carbon, silicon makes four chemical bonds and can branch out in that many directions to make long chains. In sodium silicate, the silicon atom is bonded to four oxygen atoms and is not linked in any chains. The ethyl alcohol molecule is very simple and has just two carbon atoms.

When sodium silicate and ethyl alcohol are put together, the silicate particles begin to link up with each other to form long chains as the ethyl groups (sometimes shown as "R") replace oxygen atoms in the silicate ion. Some become cross-linked between chains. Water molecules are byproducts of the formation of the polymerization bond.

The large molecule is a solid. It is a type of silicone polymer:



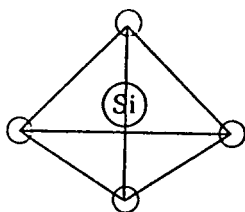
QUESTIONS

1. How did you know that a chemical reaction had taken place when the two liquids were mixed?
2. How could you find out what liquid was pressed out of the mass of crumbled solid as you formed the ball?
3. Compare your ball with those of the other members of the class. How many properties can you compare (e.g., diameter of sphere versus height of bounce)? List and compare them.

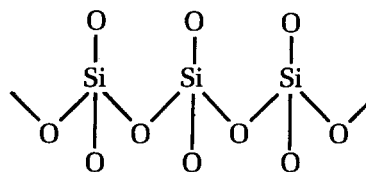
NOTES FOR THE TEACHER

Background

In this simple activity, students can easily and quickly make a rather complex polymer, silicone. Unlike carbon, silicon compounds are inorganic, and this polymer, unlike most other polymers, is an inorganic polymer. Sodium silicate consists of sodium ions paired with silicate ions as in $(\text{Na}^+)_2\text{SiO}_3^{2-}$. The silicate ion can also form a tetrahedral structure, SiO_4^{4-} , with silicon in the middle of the tetrahedron and an oxygen atom at each point of the tetrahedron. Long-chain polymers are formed by joining these tetrahedra at two corners of each to form negatively charged ions.



silicate



silicate chain

When ethyl alcohol ($\text{CH}_3\text{CH}_2\text{OH}$) is added to sodium silicate, two oxygen atoms are replaced by the ethyl groups, and cross-linking of the silicate chains occurs with water also as a product. This process produces the rubberlike polymer.

Solutions

1. Sodium silicate solution: This solution is sold in many hardware stores as water glass.
2. Ethyl alcohol: 95% ethyl alcohol works best. You might try other alcohols including isopropyl alcohol.

Teaching Tips

SAFETY NOTE: Ethyl alcohol is flammable. Extinguish all flames in the room. Dispense flammable liquids in small containers, no more than 250 mL. Restrict the total flammable liquid in the classroom to 500 mL.

1. Playing putty (e.g., Silly Putty) is a mixture of silicone and chalk.
2. Some students may find that their polymers crumble when pressed. They should patiently press all of the material to form a ball.
3. For best results, gently press the excess alcohol from the polymer as it is rolled in the palms. Wet it occasionally to make a smooth, glistening surface.
4. Neither of these solutions is toxic, but the sodium silicate is corrosive. Wear gloves.
5. The type polymer produced in such reactions generally depends on the length of the -O-Si-O-Si- chains.
6. Silicones are resistant to temperature extremes and have been widely used as gaskets in spacecraft.
7. You can add a drop of food coloring to color the ball.

Answers To The Questions

1. A solid immediately formed when the solutions were stirred.
2. The liquid is excess alcohol and perhaps a little water. You could collect the alcohol and burn it.
3. Balls will vary from smooth and round to rough and oddly shaped.

SOURCE

BORGFORD, CHRISTIE L. AND LEE R. SUMMERLIN, "Activity 32: Making a Super Ball," *Chemical Activities: Teacher Edition*. Washington, D.C.: American Chemical Society, 1988. p.p. 89-91.