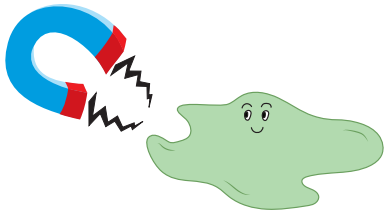
Magnetic Slime

Introduction

Making slime out of glue and borax is a popular polymer experiment in many science classrooms. With a simple addition, you can make slime that is attracted to a magnetic field!



Concepts

- Cross-linking
- Polymers
- Magnetism

Background

A typical polymer may contain thousands of monomers, "molecular units," that have been joined together by a chemical reaction. The properties of a polymer depend on the chemical nature of the monomer, how the monomers are joined together, and the length of the polymer "chain." In some cases, individual polymer molecules may be tied together into a network structure by adding a cross-linking agent.

Glue is a solution of a polymer in water. Adding sodium borate to glue produces a new type of polymer, which has been called slime or *Gluep*. Gluep is relatively easy to prepare and has some unique properties. It is a gel-like substance with properties that are intermediate between those of a liquid and a solid. Thus, the polymer gel may flow and take the shape of its container, but it can also be molded into shapes and may be elastic, like rubber. The main polymer ingredient in white glue is polyvinyl acetate or PVAC (see Figure 1).

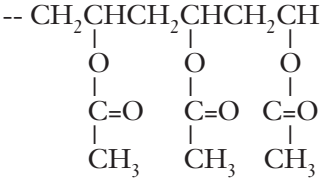


Figure 1. *Polyvinyl acetate*

PVAC is a simple addition polymer consisting of a long chain of carbon atoms with a polar acetate group ($-OCOCH_3$) on every other carbon atom. Adding a solution of sodium borate (borax) to glue leads to hydrogen bonding between the –OH groups in borate ions [$B(OH)^{4-}$] and the acetate groups in PVAC (see Figure 2). Each borate ion may bind to as many as four oxygen atoms in the same or neighboring PVAC molecules. The result is the creation of a large, fluid, three-dimensional network of polymer molecules (see Figure 3). The process by which borate ions "tie-together" neighboring polymer molecules is called *cross-linking*, and the resulting network of polymer molecules forms a gel that traps water molecules. The iron filings remain in the polymer by the force of adhesion, resulting in magnetic slime.

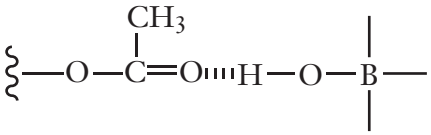


Figure 2.

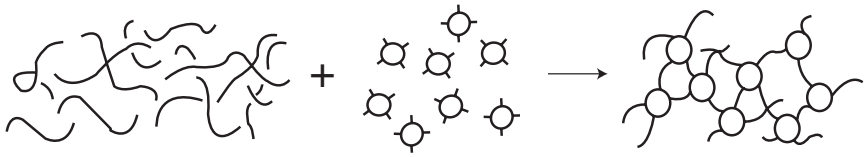


Figure 3.

Materials

Glue, white, 20 mL
Iron filings, 10 g
Sodium borate, $Na_2B_4O_7 \cdot 10H_2O$, 1 g
Water, 35 mL
Bag, resealable sandwich size
Cow magnet
Neodymium magnet
Scoop
Tape, transparent
Vials, Snap-Seal™, 45-mL, 2
Weighing dish

Safety Precautions

Sodium borate may be harmful if swallowed and large doses may damage fertility or the unborn child. Iron filings are a flammable solid. Keep away from heat, sparks, open flames and hot surfaces. Keep strong magnets away from computers and computer screens and other electronics. Use care when handling strong magnets. The magnet can quickly snap to any magnetic object, resulting in pinched fingers or cracked magnets. Store the magnetic slime polymer in plastic bags when not in use and do not allow students to take the magnetic slime polymer home. Wear chemical splash goggles and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

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Procedure

1. Measure 15 mL of water into one vial.
2. Add 1 g of sodium borate to the vial, snap the cap shut and shake for 15 seconds.
3. Set the vial aside and allow the undissolved particles to settle.
4. In a second vial, add 20 mL of water.
5. Add 20 mL of glue to the water in the second vial, snap the cap shut and shake until thoroughly mixed.
6. Pour the glue solution into a resealable plastic bag.
7. Decant the sodium borate solution into the bag, leaving any undissolved granules in the vial.
8. Add 10 g of iron filings to the bag, press the air out, and seal it closed.
9. Knead the mixture until the "slime" comes clean from the inside of the bag. *Note:* Once the slime begins to come clean from the bag, opening the bag and allowing air to enter, then resealing the bag and continuing to knead may help finish the process.
10. Remove the magnetic slime from the bag and knead a few more times until it reaches the desired consistency.
11. Demonstrate the properties of the magnetic slime.
    a. Roll the magnetic slim into a ball and set it on a table. Since the slime is quite viscous, it will slowly flatten into a thick "puddle." Next bring a cow magnet near the puddle of slime from the top. A small peak will form as the iron filings in the slime are attracted to the strong magnet (see Figure 1). Once a peak is formed, move the magnet to form another.
    b. Tape a neodymium magnet on the table next to the puddle of magnetic slime. Watch as the slime slowly engulfs the magnet (see Figure 2). If time is a factor, place the magnet near the slime without taping it down. The magnet will be drawn into the slime very quickly.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Magnetic slime may be placed in the trash according to Flinn Suggested Disposal Method #26a.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
- MS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
  - PS1.B: Chemical Reactions
- MS-PS2 Motion and Stability; Forces and Interactions
  - PS2.B: Types of Interactions

Disciplinary Core Ideas: High School
- HS-PS1 Matter and Its Interactions
  - PS1.A: Structure and Properties of Matter
  - PS1.B: Chemical Reactions
- HS-PS2 Motion and Stability; Forces and Interactions
  - PS2.B: Types of Interactions

Science and Engineering Practices
- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions

Crosscutting Concepts
- Patterns
- Cause and effect
- Structure and function

Tips

- If desired, place the cow magnet in a clear plastic bag to prevent any iron filings from sticking to the magnet.
- The properties of the magnetic slime will depend on the ratio of PVAC molecules and borate ions in the polymer network, and also on the amount of water trapped inside the gel. The 50% dilution of the glue is necessary to spread apart the polyvinyl acetate chains prior to cross-linking, otherwise, the cross-linking would occur too extensively and the fluid nature of the product would be lost. In general, cross-linking will tend to make the slime polymer more elastic, but too much cross-linking may make it brittle. If the dilution were too great, however, and the chains were too spread apart, little or no cross-linking would occur and the product would be too runny.
- A video of this demonstration without the magnetic filings, *Glue Slime*, presented by Bob Becker, is available for viewing online at www.flinnsci.com.

Materials for *Magnetic Slime* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0334	Sodium Borate, 100 g
I0011	Iron filings, 500 g
G0049	Glue, White, 1 L
AP1944	Cow Magnet
AP5666	Neodymium Magnet
FB0015	Snap-Seal™ Vials

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.