Sponsored by the INTERSOCIETY POLYMER EDUCATION COUNCIL

INTRODUCTION

For years, brave teachers have let their students mix ELMERS white glue and STA-FLO brand XXX to experience the startling change in properties that occurs. Sometimes they are at a loss to explain why this intriguing change happens. Other teachers might like to use the activity, but are scared off by the potential mess. Still others aren't sure how it fits into the curriculum in this day of "standards-based" instruction.

I hope to address these concerns by helping you explain the science to your students, by showing supervisors that making GLUE-GOO satisfies several of the National Science Education Standards [National Academy Press, Washington DC, 1996. $19.95 at 1.800.624.6242 or http://www.nas.edu], and finally, by suggesting a less messy way to make GLUE-GOO.

NOTE: There are innumerable GLUE-GOO variations. A few examples are known as NUTTI-PUTTI, GLUEP, GL00-GUE, PSUEDO-PUTTI, pHLUBBER, STICKY-ICKY, GLUAX [copyright by Capitol Children's Museum in Washington DC], POLYMER GLOBS, GOOFY PUTTY. . . .
It is not the same as OOBLECK.

This activity was developed at the 1995 MaTR Institute, POLYED National Information Center, Department of Chemistry, University of Wisconsin-Stevens Point, by Linda Stenmark [Wisconsin], Mary Helen Sparr [Missouri], and Lynn Higgins [Illinois], under the direction of John Droske, Ph.D.

MAKING GLUE-GOO: OBJECTIVES

KEY CONCEPT: Optimal formation of a cross-liked polymer gel product by varying the reactants and their amounts.

technology, inquiry-by-design, and iterative design.

major component of study . . . " NSES 177

Other CONTENT and PROGRAM standards addressed include;

All students should develop an understanding that;

Substances react chemically in characteristic ways with other substances to form new substances with different characteristic properties. 154

Technological designs have constraints. Some contraints are unavoidable, for example, properties of materials, or the weather; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics. 166

Scientists and engineers work in many different settings, including colleges and universites, businesses and industries. 169

Women and men of various social and ethnic backgrounds -- and with diverse interests, talents, and motivation -- engage in the activities of science, engineering, and related fields. Some scientists work in teams, some work alone, but all communicate extensively with others. 170

Scientists formulate and test their explanations of nature using observations, experiments, and theoretical models. 171

The science program should be coordinated with the mathematics program to enhance student use and understanding of mathematics in the study of science and to improve student understanding of mathematics. 214

TEACHER BACKGROUND INFORMATION

or

THE POLYMERIC TRUTH ABOUT GLUE-GOO.

ELMERS GLUE-ALL is an adhesive containing millions of chains [or strands] of molecules called POLYVINYL ACETATE. The polyvinyl acetate powder has been dissolved in water and the molecules are able to slip and slide easily over each other, like a pot of freshly cooked, warm spaghetti. Even though they can slip and slide, the polyvinyl acetate strands are so long that they get tangled with each other, causing the glue to be viscous (thick) and to pour more slowly than plain water.

When you add the borax solution to the glue, you cause the polyvinyl acetate chains to be linked together-just like the rungs on a ladder hold the two sides of a ladder together. The borax "grabs" onto the polymer chains, holding them tight so they can't slip and slide so easily. This produces a gel-like material that is "thicker" than the glue you started with.

NOTE: It is important to recognize that you are NOT "making" a polymer. **The polymer is already in the ELMERS GLUE-ALL.** All that is happening is that the polymer molecules that already exist in the glue, are being cross-linked, causing the surprising change in texture.

This change in properties can be modeled with **bead chain** representing the strands of polyvinyl acetate. [Bead chain, used for vertical blind controls, can be purchased from a window covering store. Take a magnet with you to make sure that it is magnetic.] Small magnets will cause adjacent chains to "link" together, just like the borax ion holds the polymer chains together. The handful of bead chains held together by magnetism has a "texture" somewhat like GLUE-GOO.

Students can also "model", or simulate, what is happening to the molecules. Have 4-6 students move to a part of the room where there is ample space. Announce to the class that each student represents a unit referred to as a **mer,** which means "unit". Ask two students to join hands and tell the class that this would be called a **dimer** because, in chemistry, **di-** means "two". If an additional student grabs on, it would be called a **trimer**, four students would form a **tetramer** and so on. Soon you would refer to the chain you are forming as a **polymer**; **poly** meaning "many". Lead the **polymer** around the room, illustrating its flexibility. Now ask five more students to join hands and form another "many-unit" chain parallel to the first polymer. This is similar to Elmer's glue in that the chains of students easily flow and move about the room.

Next the double-crosser, BORAX arrives. Ask one student to come and stand between the parallel polymer chains and hold onto the arm of one person from each chain. As the BORAX cross-linker holds firmly, the chains still can move, but much less than they could before. This is similar to what the borax molecule does in cross-linking the polymer chains together.

Much more detail on the chemistry involved and on dramatizing the bonding is available in two articles by A.M.Sarquis in the January, 1986, issue of JOURNAL OF CHEMICAL EDUCATION. The intricacies of bonding, more suitable for AP chemistry, are presented in a November, 1998, article by Bermudez, et al in J CHEM ED.

CLASSROOM MANAGEMENT / TEACHER PREPARATION

While this method is relatively low-mess, you will still want to work in a carpet-free area. Clear off the work area and be ready for some mess.

If your students are more familiar with photosynthesis than with elements, change the introduction to mention how energy from the sun is used to combine carbon dioxide, a gas, and water, a liquid, to make glucose [sugar] in the process called photosynthesis.

I insist that my high school chemistry students get more "involved" in the chemistry of GLUE-GOO by forcing them to mix it with their fingers. I know that I have them hooked when I hear "ooooOOO! That's so nasty." Just have them mix the glue and borax in a 3 or 5 oz disposable cup, rather than inside a baggie. Old 35mm film canisters also work.

If the students take the GLUE-GOO home, be sure and send along an information sheet similar to this.

NOTE TO PARENTS:

Your student made some GLUE-GOO today. It is made from just water, Elmer's GLUE-ALL and 20 Mule Team BORAX. All are non-hazardous household chemicals.

HOWEVER, as with any glue product, keep the GLUE-GOO off of carpet, upholstered furniture, or hair. It's glue!

Do NOT allow very young children to play with it: They could choke.

Store the GLUE-GOO in an airtight container so that it does not dry out.

It it becomes moldy, put it in the trash. [It keeps longer if stored in the refrigerator.]

Remove paper towels and turn off water at student benches. Trust me, there will be a lot less total mess if they mostly clean up using the GLUE-GOO [sort of like cleaning up rubber cement] before they get any water or paper towels involved.

Have a small bottle of glue and a wash [squeeze] bottle of borax solution at each work area to fine tune the GLUE-GOO.

It will take several minutes of kneading, during which some students will become discouraged. Encourage them to just keep on kneading and adding small amounts of glue or borax. Eventually most find the right mix.
The final proportions turn out to be about 4 parts thinned glue to 1 part of the borax solution.

Add food coloring to the glue or borax, if desired.

AFTER hands and desk are clean, they get a clean baggie to store the GLUE-GOO in. Only then do they get to wash hands with warm soapy water, if still needed.

The GLUE-GOO will mold if not stored in the refrigerator. I have some that is years old. I just bring it to a boil in the microwave every few months to "sterilize" it.

For about 30 students, do this in advance:

1. Dilute ELMER'S GLUE 1:1 with water [2 cups glue and 2 cups water]. [Some Office Depots sell GLUE-ALL by the gallon.]

2. Mix 2 tablespoons of 20 MULE TEAM BORAX into 2 cups of water. [Don't use Borateem: That's a detergent, with very little borax. You should be able to find BORAX in the laundry products section of a large supermarket.]

3. Continue at Step 1 on the Student Directions.

MAKING GLUE-GOO:

Often in chemical reactions, the REACTANTS [starting materials] have very different properties from the PRODUCTS [ending materials]. Consider how different the two elements, the soft, reactive metal sodium, plus the poisonous, green gas chlorine, are from their compound, sodium chloride, or table salt!

You will use your muscular energy to "react" glue and borax to produce a very different product-

GLUE-GOO

MAKE THE GOO:

1. Measure 2 tablespoons (30 mL, about one ounce) of the glue+water mixture into a sturdy zip-top sandwich bag.
2. Add 2 teaspoons of the borax solution, to the bag with the glue.
3. Zip firmly closed. FIRMLY CLOSED. Check that zipper!
4. Knead it, mix it, moosh it, lomi-lomi it, inside the bag. It will take several minutes.
5. When it is somewhat solid, take it out of the bag and continue to mix it in your hands. Discard that bag.
   A. Too runny or stringy? Add a few drops of glue.
   B. Too sticky? Add a few drops of borax solution.
   C. DO NOT ADD ANY WATER or use paper towels to clean up.
6. Keep kneading. The texture will improve as you “excercise” it.

EXPERIMENT WITH GLUE-GOO (Thanks to Marie Sherman of St Louis)

7. Form it into a ball and set it on a clean surface? Does it keep its shape? Is GLUE-GOO a solid or a liquid?
8. Try to pull it into a thin film, or tear it into little pieces.
9. Will a ball of GLUE-G00 bounce if dropped on a table?
10. Roll GLUE-G00 into a "snake".
    a. Pull on the “snake” gently. Does it stretch or does it break?
    b. Pull on it quickly. Stretch or break?
    c. Write a message on paper with washable marker. Press a piece of GLUE-GOO on it. Does the writing transfer to GLUE-GOO?
11. What other experiments can you devise?

STUDENT BACKGROUND INFORMATION

A POLYMER is a huge molecule made up of thousands of identical small molecules linked together. It is like a beadchain, or a long chain of paper clips all hooked together. Examples of natural polymers are wood, muscles, rubber, bread [cooked starch], and natural fabrics such as cotton and silk. Think. . . Is it soft? squishy? stretchy? bendy? Maybe it's a polymer!

Human-made, or synthetic, polymers are becoming more and more a part of our daily lives. PLASTICS are examples of synthetic polymers. By combining glue, borax and water in various proportions, you will make a fun new polymer product. The properties of this material vary considerably depending on the proportions of ingredients you use, and how you combine them.

Most brands of white glue contain millions of individual strands of a molecule called polyvinyl acetate which have been dissolved in water. Before you add the borax cross-linker, these chains are able to slip and slide freely over one another like strands of freshly cooked spaghetti. Although they can slip around, the polyvinyl acetate chains are so long that they tangle in each other, causing the glue to be thick and to pour more slowly than water.

When you add the borax solution, you cause the polyvinyl acetate chains to be linked together -- just as rungs link the two sides of a ladder to each other. The borax forms bridges with the polymer chains, binding them together (cross-linking them) and producing a gel-like material that is thicker and different than the glue solution. Properties of this GLUE-GOO material will vary with the amount of cross-linking, and the amount of cross-linking varies with the proportions of the ingredients, additives, and with the mixing process. Which combination of ingredients is right? The "perfect" product is the one whose properties best match the intended use.
Have fun!

KEY CONCEPT: Optimal formation of a cross-liked polymer gel product by varying the reactants and their amounts.

CURRICULUM CONNECTIONS: Problem solving, observing, making hypotheses, changing variables.

SCIENCE TECHNOLOGY AND SOCIETY CONNECTIONS: Working cooperatively in a team, verbal and written communications, economics as a driving force for technology, inquiry-by-design, and iterative design.

NATIONAL SCIENCE EDUCATION STANDARDS: I use this activity primarily to model the "structure-properties" connection. "The relationship between properties of matter and its structure continues as a major component of study . . . " National Science Education Standards [National Academy Press, Washington DC, 1996. $19.95 at 1.800.624.6242]

Other standards addressed include;

As a result of activities in grades 5-8, all students should develop an understanding that

> Substances react chemically in characteristic ways with other substances to form new substances [compounds] with different characteristic properties.
>
> Technological designs have constraints. Some constrains are unavoidable, for example, properties of materials, or the weather; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.
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> Scientists and engineers work in many different settings, including colleges and universities, businesses and industries.
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AUDIENCE: This activity is appropriate for a wide range of students because of the easy availability and nontoxic nature of the materials involved.

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Now, you're ready to make the GLUE-GOO

3. Measure 2 tablespoons (30 mL, about one ounce) of the glue+water mixture into a sturdy zip-top sandwich bag.
4. Add 2 teaspoons, or 2 "squirts" of a beral pipette, of STA-FLO, or the borax solution, to the bag with the glue.
5. Zip firmly closed. FIRMLY CLOSED. Check that zipper!
6. Knead it, mix it, moosh it, lomi-lomi it, inside the bag. It will take several minutes.
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For much more information about GLUE-GOO, and other polymers,
lynhiggins@aol.com or visit www.polymerambassadors.org