Science of Slime

An investigation into the physical properties of cross-linked polymers for High School Chemistry

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Summary

Many high school chemistry students get the chance to experience a polymer-based lab in school, and sometimes it comes near the end of the year as a "fun lab." Various laboratory exercises I have seen and used in the past involve making such materials as gluep, gak, or slime, and often use generic household materials. In this experiment, students will be utilizing what I have seen called the "commercial" or "institutional" slime.

This lab activity utilizes poly (vinyl alcohol), PVA, and a borax solution to process the slime. The sheer size of the PVA molecules (average molecular weight can surpass 100,000 grams per mole) provides students with a real-world example of how large organic molecules can become. Handling the viscous slime, along with seeing the figure of cross-linking in the handout, further illustrates how large and cumbersome some organic molecules are. Finally, leaving flexibility for students to schedule their own concentrations for the final two trials, as well as leaving the data and observations space blank on the handout, allows students to take greater control of their research. As this lab is best suited for the end of the year, during discussion of polymers, students should be familiar with designing and adapting procedures and with proper data recording techniques.

Connection to the New York State Regents Chemistry Core Curriculum

Key Idea S2.1

Devise ways of making observations to test proposed explanations.

- design and/or carry out experiments, using scientific methodology to test proposed calculations

Key Idea 3.2c

Types of organic reactions include: addition, substitution, polymerization, esterification, fermentation, saponification, and combustion.

Key Idea 5.2n

Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point.

Time constraints

This lab is best done in an 80 minute block, to give opportunity for discussion prior to, and following, the experimentation. You will definitely want 10 minutes saved for cleanup purposes.

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Modifications

For 40-minute periods, have students fully prepared by reading the material before coming to lab, as well as answering the few pre-lab questions. If the experiment is still taking too long, you can cut the activity to two trials instead of three.

For 80-minute periods, if there is time at the end of class, investigating the creeping properties of slime (hanging it in air and measuring its stretching motion due to gravity) is one possibility. This is also a great time to mention silly putty and do some demonstrations.

Pointing out Silly Putty's official website, www.SillyPutty.com, can be a great way to get more interested students started developing their own tests with cross-linked polymers.

For some students who work slower in lab situations, two trials should give just as good results as three (it is just better to have three points of data).

Preparing the Solutions

4% poly (vinyl alcohol)
This solution will be your largest time-consumer during setup. Poly (vinyl alcohol) usually comes in granular form, and even though it is supposedly very soluble in water, the sheer size of the molecules makes dissolving it a very slow process. Each group will need 90 – 100 mL of the 4% solution, so depending on the number of students and the number of students per group, I figure this to be about one liter of solution per class.

For each liter, dissolve 40 grams of PVA to a volume of one liter of distilled water. If you have a large magnetic stirring/heating plate, it will come in handy. It is best to dissolve the solution under constant stirring in the 80 - 90°C range. If water boils or if too much evaporates, a film of PVA will begin to develop on top of the solution. If you add too much PVA at once, the granules will begin to clog in the water before they can dissolve. Definitely do this step in advance, as it keeps well if you stopper it and may take you 1-2 hours to dissolve a liter.

Alternatives include buying PVA already in solution. While slightly more expensive, it can save a lot of headaches. Others have suggested using crockpots on low setting over night, stirring every half hour while you are awake. Low setting should keep it from boiling. I have not tried this method yet, but it is supposed to work well.

4% borax solution

Dissolve 40 grams of borax (also, sodium tetraborate) per liter of solution with distilled water. Each group will use 25 mL of solution, though some may have extra remaining. For every liter of poly (vinyl alcohol) you will need 250 mL of borax solution. The borax

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should dissolve quickly with warm water and stirring. This solution should also be kept in a stoppered bottle.

References

The following references add insight to others' approaches to the slime activity, silly putty activities and information on cross-linking polymers. All websites last accessed August 12, 2004.

Herr, N & Cunningham, J. (1999) *Hands-on chemistry activities with real-life applications.* San Francisco: Jossey-Bass.

"Lecture Connections: Polymers". http://icn2.umeche.maine.edu/newnav/Homepage/Highschool/Slime/lecpolymers2.htm

"Polymers: Experiment 2". http://matse1.mse.uiuc.edu/~tw/polymers/e.html

"Silly Putty University Campus". http://www.sillyputty.com/

"Steve's Place-Slime". http://www.steve.gb.com/science/slime.html

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