

Slime

Materials:

- 4% polyvinyl alcohol (PVA) solution - 50 mL per group
- 4% sodium borate solution (borax)
- 5 oz. paper cup
- wooden craft stick
- food coloring
- plastic zip top bag

Safety:

- Lab aprons and safety glasses/goggles should be worn.
- The borax and the PVA will burn the eyes. Hands should be washed at the end of the lab.

Procedure:

Divide students into 5 groups. Assign each group one of the following "recipes":

<u>Team</u>	<u>PVA</u>	<u>Sodium borate solution</u>
1	50 mL	1 mL
2	50 mL	2 mL
3	50 mL	4 mL
4	50 mL	6 mL
5	50 mL	10 mL

1. Add PVA to paper cup.
2. Stir in food coloring if desired. (just a few drops)
3. Add sodium borate solution. Stir quickly with a wooden craft stick making sure to scrape the sides and bottom.
4. Pour entire contents of the cup into a plastic zip top bag and knead.
5. Take slime out of bag and "investigate" properties.
6. Have groups compare properties of the different slimes:
 - bouncing
 - stretching slowly
 - stretching quickly
 - letting it "pour" from one hand to another
 - flow rate through a wide mouth funnel
 - etc.....

Have the students record the appearance and characteristics of the PVA at each step. This

method of doing the slime lab allows the students to work as teams and then causes the teams to interact to make comparisons. The students sometimes struggle to find the words to describe the slime in step #6 - encourage them to devise some sort of chart or graphic organizer to record their results/conclusions.

Notes:

By having different groups use different amounts of sodium borate solution, students should be able to more easily determine the effects of cross-linking on the properties of the polymer. The more sodium borate used, the more cross-linking that occurs. Each batch of slime is 96% water but they do not have the same viscosity. It should be emphasized that the students did not make polymer chains. The polymer chains are dissolved in the water in the PVA solution; they were already there. The sodium borate just "ties" the polymer chains together making it a more cohesive mass.

Polymer chains are formed by covalent bonds which are strong bonds. In making slime, individual polymer chains are "hooked" together by weak hydrogen bonds. It is evident that this cross-linking is weak because of the ease with which the slime pulls apart. It is sort of like "tying" together strong strands of string with limp strands of cooked spaghetti. Even though this cross-linking is weak, it does alter the properties of the polymer.

Have the students leave some of the slime stretched out on a counter overnight. The water will evaporate and the PVA will become a dry, brittle film that is mostly transparent. Also, pour some PVA solution that has **not** been cross-linked with borax on the counter. It will dry into a more flexible film much like the water soluble laundry bags used by hospitals. It is possible to mass a sample of each team's slime both before and after drying and calculate the percentage of water in each. This will provide evidence that each type of slime was indeed 96% water and that the difference in properties was not due to the amount of water but to the amount of cross-linking.

An observation that the students can make is how cool the slime feels. As the slime is stretched it has more surface area exposed to air and the evaporation rate of the water is increased. What they are feeling is the effect of evaporative cooling.

The PVA solution can be made using a stirrer hot plate. But it is much faster and easier to make it using a microwave oven. Do not let the solution boil whichever method you use. Boiling will alter the properties.

A beaker may be used to make the PVA solution. Add 4 grams of PVA powder to 96 mL of tap water and stir. The PVA will suspend briefly but will not dissolve until heated. To make larger amounts just multiply the amount of ingredients by the appropriate factor. Cover the beaker with microwaveable plastic wrap and stir between heating segments. Microwave for 2 - 3 minutes at a time depending on the amount of solution. Heat to 80°C. Microwave an additional minute at a time if needed. The prepared solution should be clear and somewhat viscous. The PVA solution will often still look slightly cloudy at this point but it will clear upon sitting. Do not heat above 80°C. The solution stores well in the refrigerator until needed.

The PVA solution is sticky. Have the students try to figure out a way to measure the required

amount of PVA without putting it into a graduated cylinder. This is a quick, simple opportunity for them to problem solve. The students can measure 50 mL of water in a graduated cylinder, pour it into a cup, and then mark the fluid level. Pour out the water. Add PVA to the mark. Some students will usually figure this out for themselves. It really saves on clean-up. It is also helpful to store the PVA solution in PETE bottles (#1 recycling) with nipple-style caps. These are much easier to pour from and create less mess. Students often add too much food coloring. To avoid this problem, add the food coloring to the bottles of PVA solution prior to the lab.

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