STEM gems

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GLUE SLIME

big IDEAS

ITS SLIME TIME! In this STEM Gem, you will use Andy the Science Wiz's touch to make classic glue slime. There are often a lot of oohs and aahs when young people make slime. But is real science taking place? In this special version of the activity, young people will be amazed at how many different types of glue can be used to make slime. They will also perform an investigation to find out which type of glue makes the best slime using criteria and experiments that they determine and design.

WHAT IS A POLYMER?

A polymer is made from special molecules joined together to create long chains consisting of thousands and thousands of molecules. In ancient Greek, poly means many and mer means part, so polymer literally means many parts. In some polymers, the long chains are free to slide over each other, making the polymer behave like a thick liquid. These polymers are called loose-linked polymers. Other polymers have an additive that causes cross-linking. The polymer chains stick to one another and become tangled together, making the polymer stiffer. These types of polymers are called cross-linked polymers. All types of plastics are made from polymers. The harder the plastic, the more it has been cross-linked.

WHAT IS SLIME?

Slime is a fluid polymer created by mixing sodium borate (a linking agent) and glue (a polymer). When the solution is mixed, the sodium borate bonds, or attaches, to the polymer chains, which causes the chains to stick together, becoming thicker and more slime-like. This process is known as cross-linking. The slime created in this STEM Gem activity is made from a common polymer that can be found in many types of non-toxic glue, called polyvinyl alcohol, or PVA. PVA is a loose-linked liquid polymer. When sodium borate (borax dissolved in water) is added to PVA, a chemical reaction takes place that makes the long PVA polymer chains stick to one another. The long PVA polymer becomes cross-linked, thickening the glue and creating slime!

WHAT IS A FAIR TEST?

One of the most important components of a good science experiment is conducting fair tests. In a fair test, only one variable is changed at a time and all other conditions are kept the same. A fair test helps scientists determine whether the change affected the results. It would be difficult to know which change affected the results if more than one variable were changed. Fair tests also help scientists reproduce the results, which is another important component of a good science experiment.

There are three ingredients in this slime recipe: water, sodium borate, and glue. To find out what type of glue makes the best slime, the only ingredient that should be changed is the polymer base or glue. Young people will discover which type of glue makes the best slime by testing the physical characteristics of each sample of slime. When experimenting with the different types of slime, it is important to keep all experimental variables the same except the one being tested; the type of glue in this case. All other variables have to be kept constant to ensure that the only difference affecting the outcome is the type of glue used. For example, all portions of the slime being tested must be the same. If testing how high the slime can bounce, each sample has to be dropped from the same height. All measurements of each ingredient must be the same when making each type of slime.

SCIENCE talk

CROSS-LINKED POLYMERS
Polymer chains consisting of thousands of molecules that bond together to form tangled knots that make the polymer stronger and harder.

FAIR TEST
An investigation where only one variable is changed. A fair test is used to determine the differences that the one variable influences.

MOLECULE
A unit of matter; two or more atoms chemically bound together to form a substance.

PHYSICAL PROPERTIES
Anything that is observable and measurable for a particular object.

POLYMERS
Special molecules made from long chains of smaller molecules joined together.

VARIABLE
Something that can be changed from one experiment to the next.

engage

Select an object in the room. Show it to the group and ask young people to describe it in detail. *Young people's choice*

What are the physical properties of an object? *Physical properties describe an object's characteristics. A physical property is anything that is observable and measurable. For example, the physical properties of a ball are its size, shape, color, weight, texture and how high it can bounce.*

What slimy things can you think of? *Young people's choice and might include: snails, mucus, pond scum, raw eggs, hair gel, glue, or jelly*

What physical properties should the perfect slime have? *Young people's choice and might include: wet, sticky, stretchy, green, or bouncy*

What are some of the rules we should have when working with chemicals? *Explain the following Chemistry Safety Rules and ask for additional ideas. Note: Contrary to youth development practices, two of these rules are stated in negative terms to communicate explicit safety expectations. (1) Do not eat or drink any chemicals at any time. (2) Do not touch or smell any chemicals at any time. (3) Listen carefully and follow all directions. (4) Use both hands for stirring and pouring and keep mixing containers flat on the table while mixing. (5) Ask to have things passed instead of reaching across others. (6) Wash hands before and after any experiment. (7) Keep paper towels nearby to clean up spills.*

what YOU WILL NEED

NOTE: Each young person will make slime using one type of glue from a range of available PVA, non-toxic options. The size of the group will dictate how many different types of glue are needed. This experiment is flexible. Young people can simply contrast and compare two types of glue or add more types to increase the variety. See the photo for possible types of glue available for purchase.

The recipe ratio that provides a nice amount of slime to experiment with is 1-oz glue to ½-oz water to ½-oz sodium borate. Most supermarkets should stock 1-oz or 2-oz condiment cups. The directions in this activity are based on 1-oz cups. Amend the directions to fit the size of measurement cups you have available and the amount of slime you want each young person to make.

FOR EACH CHILD:

- **1-oz PVA-based glue** *(Most types of non-toxic glue are PVA based. To ensure a type of glue is PVA-based, test a sample of the glue by adding a small drop of sodium borate to see if it forms slime)*
- **½-oz sodium borate** *(borax solution, see Before You Begin)*
- **2 craft sticks or straws for mixing**
- **2 small 1-oz or 2-oz portion cups** *(for the glue and sodium borate)*
- **1 small 3 to 5-oz paper cup**
- **Small re-sealable plastic bag**
- **Sheet of paper towel**

FOR THE GROUP:

- **A variety of PVA-based glue** *(at least two types)*
- **Water**
- **Pan**
- **Heat source**
- **One tablespoon measuring spoon**
- **Mixing spoon**
- **Box of borax**
- **Clean, empty bottle to transport the borax solution**
- **Clean water bottles or cups for water distribution**
- **Empty cups for slime waste water collection**
- **Pens**
- **Paper**
- **Rulers**

& before YOU BEGIN

FOR DAY BEFORE:

1. **Make the borax solution.** Begin by boiling enough water in a pan to give each child at least one-half ounce. Carefully add one tablespoon of borax at a time to the water. Add three tablespoons of borax for every cup of water. Stir the solution thoroughly to dissolve as much borax as possible and let the solution cool before allowing young people to experiment with it.
2. **Pour the borax solution into a container,** such as a clean water bottle, once it has cooled. This will enable you to easily pour the solution during the activity. Label the bottle as borax solution.

JUST BEFORE THE ACTIVITY:

1. **Write the name of each type of glue that young people will be testing on a sheet of paper.** Squeeze a nickel-sized circle of each type of glue next to the corresponding name written on the paper. Make one glue-identification sheet for each group of five young people.
2. **Fill clean, empty bottles or cups with water** and distribute throughout the activity area. Label each container as water.

EXPLORE & EXPERIMENT

1. **Share the different types of glue** young people will be experimenting with and invite them to examine each.

2. **Explain that each type of glue is made from a polymer called PVA.** Tell young people that a polymer is a group of special molecules made from smaller molecules joined together into long chains. Explain that by adding another chemical to the glue, the PVA can be made to crosslink, or stick to itself, to create a special kind of polymer that feels like slime.

3. **Tell young people that they will do experiments** to find out which type of glue makes the best slime.

4. **Give each young person a craft stick.**

5. **Distribute each glue-identification sheet made prior to the activity.** Encourage young people to use their craft sticks to investigate each type of glue.

6. **Invite young people to describe what they observe about each type of glue.** Encourage them to compare and contrast the physical properties of each type, such as is each type thick or runny.

7. **Have young people dispose of their craft sticks** and glue-identification sheets.

8. **Invite young people to pick the glue they think will make the best slime.** Encourage each young person to share his or her choice and why he or she selected that type of glue. If necessary, use some gentle persuasion to ensure that every type of glue is selected.

9. **Have each young person gather a clean craft stick**, two 1-oz (or 2-oz) portion cups, a small paper cup, and a sheet of paper towel for containing spills.

10. **Invite young people to fill one portion cup** with one ounce of their selected glue.

11. **Have young people use the water provided** in the pre-filled bottles or cups and pour one-half ounce of water into their second portion cups.

12. **Invite young people to pour the glue and water into the paper cup** and use their craft sticks to mix the liquids.

13. **Ask young people to describe the result and if the solution looks slimy.** Explain that the polymer has only been watered down and should not be very slimy yet. A special chemical is needed that will crosslink the PVA polymer in the glue. This will make the PVA stick to itself and become thicker.

14. **Have young people set aside their empty portion cups used for the water.** Pour one-half ounce of borax solution into each young person's cup. Invite young people to assist when appropriate.

15. **Invite young people to add the sodium borate (borax solution)** to the water-glue solution and stir with a craft stick.

16. **Ask young people to describe what is happening in their cups.**

17. **Distribute empty cups to the group.** Have young people pour any leftover liquid from their slime cups into the empty cups while holding their slime with their craft sticks.

18. **Invite young people to pick up their slime and explore it.** Ask them to describe or write down some of the physical properties of their slime, such as temperature, color, weight, texture, sounds it makes or whether it is wet or dry. Each type of slime will feel cold. Although making slime is a chemical reaction that takes heat to work, the slime feels cold because it absorbs heat to form the cross-linking chemical bonds.

19. **Tell the group that you want them to find out which glue made the best slime.** They will first need to determine how they will judge the best slime. Have the group discuss a set of criteria that defines the perfect slime. For example, they may conclude that the perfect slime is stretchy, bounces, and feels wet. Have the group decide on two to three criteria and write them on a sheet of paper.

20. **Challenge young people to design an experiment to test each of the different criteria that they have picked to define the perfect slime.** Allow them adequate time to brainstorm, as designing experiments can be very challenging. For example, they might test bounce by using rulers to measure how high a ball of slime bounces when it is dropped. They might also test stretch by measuring how far it can stretch before it breaks. And they might test wetness by placing the slime on a dry paper towel for 30 seconds and measure the size of the watermark left by the slime. Remind the group that each experiment needs to be a fair test in which only one variable must change. In these experiments, young people are testing which glue makes the best slime, so the only variable that should change is the type of glue used. When conducting a drop test for bounce, the height the slime is dropped from, the surface the slime is dropped on, and how the height is measured should be the same when testing each type of slime. When conducting a stretch test, consider the speed used when stretching the slime and if it matters how fast or slow it is stretched. Each sample of slime should be stretched at the same rate of speed.

21. **Invite young people to perform their experiments on each type of slime they made.** For younger children, the experiments can be done together as a large group, using one sample made from each type of glue. For older children, have them form small groups so that each small group has a sample of slime made from each type of glue. Then encourage each small group to conduct each experiment five times to get a series of trials that they can average. Have each group record their results and share with the group when all experiments are completed.

22. **Have young people join as a large group** and vote for the glue that made the best slime based on the criteria they selected and tested.

23. **Encourage young people to place their slime in re-sealable plastic bags to take home.** Remind them that the slime is non-toxic, but is not edible and should be kept away from younger children and pets.

make THE CONNECTION

ASK YOUNG PEOPLE HOW THEY WOULD TEST WHETHER SUNLIGHT AFFECTS PLANT GROWTH. Invite young people to answer the following questions: What experiments can be done? What variables would need to be considered? What variables would change and what variables would have to stay the same to ensure reliable results?

One example of an experiment might be to place one plant in the dark and one plant in the sunlight. All variables should be the same except the amount of light the plants receive. The type of plant, type of soil used, type of planting pot, and watering schedule should be the same for both plants. Each plant's growth should be observed and recorded over a specified period of time.

EXTEND & EVALUATE

Have young people record the results of their experiments as a graph. A bounce test or stretch test creates results that are ideal for recording in a graph format because the results are number quantities. Younger children can create a simple bar graph showing one measurement for each type of slime for each type of test. Older children can record the results of several test trials by marking points on a line graph above the name of each type of slime.