LIGERBOTS ▪ FIRST Robotics Team 2877
info@ligerbots.org ▪ www.ligerbots.org ▪ #FRC2877 ▪ The LigerBots ▪ @ligerbots ▪ @ligerbots_frc2877

Slime

Ingredients

- *1.5 tsp. baking soda*
- *1 Tbsp. contact lens solution that contains borax*
- *4 fluid oz. Elmer's glue*
- *food coloring*
- *plastic cup or bowl*
- *popsicle sticks for stirring*

1. Pour the glue into your cup or bowl.

2. Add your choice of food coloring and mix with a popsicle stick.

3. Add the baking soda and mix again.

4. Add contact lens solution and mix until the slime gets harder to mix.

5. Take the slime out of the cup and knead it with both hands.

6. Stretch and check for consistency. If sticky, add 3/4 tsp contact lens solution.

Slime Activities

1. *Confirm that your slime is a liquid.* Put your slime into three or more containers with different shapes. Observe how the slime moves around and takes the shape of its new container.
2. *Test and change the viscosity of your slime.* Observe the rate at which the slime stretches towards the table when you hold it up high and let gravity pull it towards the ground. See if you can figure out how to make it more stretchy or more bouncy by adding more baking soda or more contact lens solution. Add a few drops of contact lens solution (acidic) and observe how your slime becomes more liquid. Then add a little baking soda (alkaline) and observe how the slime becomes more viscous again.
3. *Test the response of your slime to "shear force."* Drop your slime onto a hard, smooth surface (like a floor or table) from high up to see how much it bounces from different heights. Slowly squish it onto the surface with the palm of your hand with varying degrees of force to see how it gets harder or easier to spread. Rip your slime abruptly into two pieces to observe how it tears.

Test and change the viscosity of your slime.

Test your slime's response to "shear force."

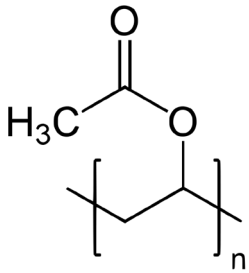
The Science Behind Slime

Slime is a cross-linked polymer. It is made from the reaction between glue containing long-chain polyvinyl acetate molecules and contact solution containing borax.

The molecules in glue look like strands of spaghetti. These molecules can slide past each other only with difficulty, so the glue doesn't gush from the bottle, it has to be squeezed out. Borate ions in the contact solution react to link the long glue molecules to each other, making even bigger molecules. The strands of spaghetti become one big mass that we know and love as slime.

The cross-linked polymer traps a lot of water, so slime is wet. You can adjust the consistency of slime by controlling the ratio of glue to borax and baking soda. If you have more glue, the slime will be more liquid (less viscous.) If you have more borax or baking soda, the slime will be more solid (more viscous.)

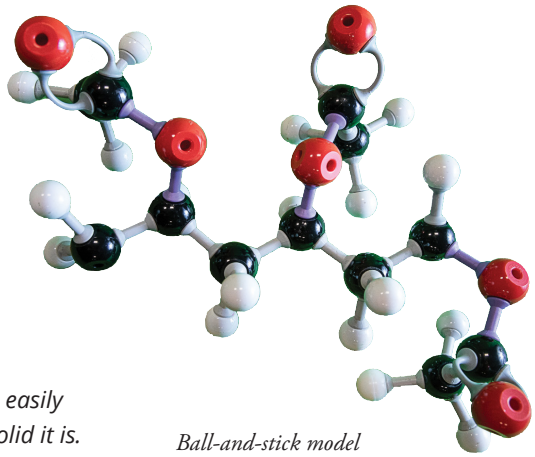
Slime thickens with force, but breaks when torn. Slime is a "shear thickening" fluid, meaning that the more force that is applied to it the thicker (more viscous) it becomes. If you drop slime it acts like a solid and bounces, but if you slowly squish slime it acts like a liquid and stretches. However, if you tear slime apart it will break abruptly. Squishing allows the cross-links to break and re-form, but tearing severs the cross-links between the molecules faster than the connections can re-form.



Line structure of a polyvinyl acetate monomer.

Here is some chemistry, for more advanced understanding:

- *Adding baking soda (sodium bicarbonate) to glue increases the speed of (catalyzes) the reaction between the polyvinyl acetate and the water in the glue. This reaction creates polyvinyl alcohol.*
- *The contact lens colution contains borate ions, created in several chemical steps when borax is mixed with water at the contact lens solution factory.*
  - *Borax + water = sodium ions + tetraborate ions.*
  - *Tetraborate ions + water = boric acid.*
  - *Boric acid + water = borate ions + hydrogen ions.*
- *Each borate ion reacts with two polyvinyl alcohol chains, linking them so they can't easily move. (This is called "cross linking.") The more cross links the slime has, the more solid it is.*



Ball-and-stick model of polyvinyl acetate.