Investigating cross-linking – making slime

PVA glue contains the polymer polyvinyl alcohol (also called polyethenol) and has the structure:

![Polyvinyl Alcohol Structure]

Borax forms the borate ion when in solution. This ion has the structure:

![Borate Ion Structure]

The borate ion can make weak bonds with the OH groups in the polymer chains so it can link the chains together as shown below. This is called cross-linking.

![Cross-Linked Structure]

This cross-linking changes the properties of the polymer from a viscous liquid to a far more viscous slime. The slime contains as much as 96% water trapped between the molecules.

**Investigation**

Find out how the viscosity of the slime changes as the amount of borax used changes.
What you need

- PVA solution
- Borax solution (Minimal hazard)
- 4 x 100 cm³ beakers
- 1 x 25 cm³ measuring cylinder
- 1 x 10 cm³ measuring cylinder
- Stirring rod.

Health and safety

The chemicals used in this practical are of minimal hazard, although borax is a weak alkali and is a poison if you eat a large amount of it. Wash your hands at the end of the experiment and certainly before you eat or drink anything.

If you have eczema, sensitive skin or cuts on your hands, wear disposable gloves.

Basic slime mix

Put 20 cm³ PVA solution in a beaker. Add between 1 and 10 cm³ borax solution (make sure you know how much you have added). Stir vigorously for several minutes to ensure the PVA and borax are thoroughly mixed. Leave the mixture for a few minutes for all the cross-links to form and then remove it from the beaker and roll it into a ball.

Testing for viscosity

There are several ways you could do this – a couple of suggestions are given here, but there are many other ways too.

- Put the slime in a small beaker and leave it to settle. Place a coin on the surface and time how long it takes to sink.
- Draw a circle on a piece of paper about the size of a small beaker. Draw another circle outside the first one, about 1 cm away. Put an overhead projector slide on top or put the paper into a plastic wallet. Roll your slime into a ball and put it in the middle of the circles. Start timing when the slime reaches the first circle and stop when it reaches the second.

Recording your results

Record your results in a table. Plot a graph of the property you measured against the volume of borax used.

Explaining your results

- Describe what your results show. Are you surprised? If so, why?
- Try to explain your results in terms of cross-linking.