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77. Polymer slime

Topic

Polymers, acid base reactions, equilibrium.

Timing

60 min.

Description

Students make a polymer slime and test its properties.

Apparatus and equipment (per group)

- Plastic teaspoons
- Plastic or disposable cups (100 cm^3 beakers could be used)
- Food colouring or fluoroscein dye
- 100 cm^3 Measuring cylinder
- Watch glasses or petri dishes
- Two dropping pipettes. Use the type of teat pipette (usually fitted to Universal Indicator bottles) that do not allow squirting. – *eg* Griffin.

Chemicals (per group)

- Polyvinyl alcohol solution (4 per cent)
- Borax (sodium tetraborate) solution 4 per cent (one quarter the volume of polyvinyl alcohol solution).
- Sodium hydroxide solution 0.4 mol dm^{-3} (**Irritant**)
- Hydrochloric acid 0.4 mol dm^{-3} (**Irritant**).

Polyvinyl alcohol solution
To prepare the polyvinyl alcohol solution use hydrolysed polyvinyl alcohol powder (available from BDH). To prepare a 4 per cent solution, weigh 40 g of hydrolysed polyvinyl alcohol. Gradually heat 1 dm^3 of tap water to 50 °C, then gradually sprinkle the solid polymer across the surface, while stirring constantly (best with a hot plate magnetic stirrer). Continue heating to 90 °C gradually, and stirring. Do not overheat or boil the solution. The solution should appear colourless and clear at this point, with practically all solids dissolved. Remove from heat; cover with aluminium foil and allow to cool overnight. The solution can be kept for quite a period of time stored in plastic bottles.

Borax solution
Prepare a 4 per cent w/v solution in water. Calculate what total volume of solution is required for the class to weigh out the appropriate amount of borax. The student should add approximately one quarter of the volume of the polyvinyl alcohol solution.

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Background theory

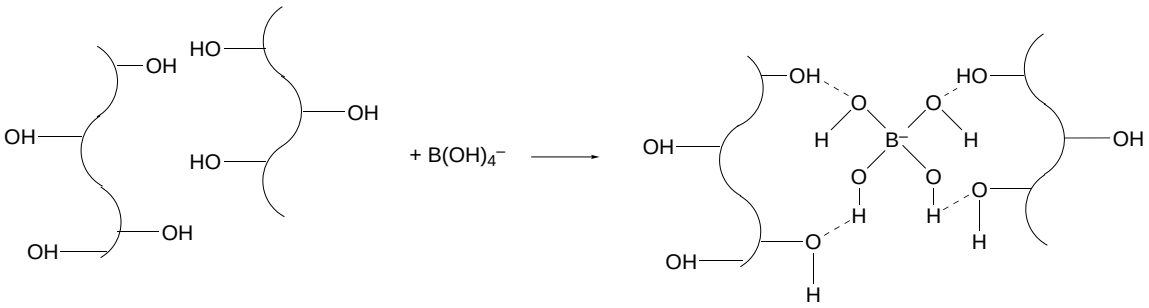
Polyvinyl alcohol is an addition polymer formed from vinyl alcohol. The polymer can dissolve in water as a result of the OH (hydroxyl) groups attached to the main polymer chain, which form hydrogen bonds with water molecules.

It is helpful if students understand:

how polymers are formed from monomers, the concept of equilibrium and that an equilibrium exists

$B(OH)_3 + 2H_2O \rightleftharpoons B(OH)_4^- + H_3O^+$

The $B(OH)_4^-$ ion is believed to crosslink the polymer chains as shown



Safety

Wear eye potection. The polyvinyl alcohol and borax solutions are non-toxic, but wash your hands when finished. Students should not take slime home.

Answers

1. Slime stretches.
2. Slime breaks.
3. Slime bounces.
4. Slime does not break, but instead thickens under stress.
5. Slime dissolves water-based ink, so writing is taken up on the slime.
6. The acid destroys the properties of the gel because bonds between the chain are broken.
7. The base restores the properties of the gel because it neutralises the acid allowing the crosslinking to occur again. Discussion of acid base equilibria can be involved here, since tests 6 & 7 can be repeated and the same results obtained.

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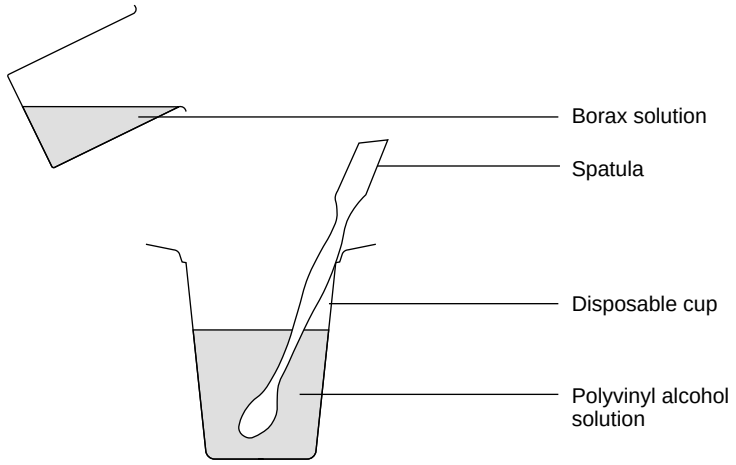
Polymer slime

Introduction

A solution of polyvinyl alcohol can be made into a gel (slime) by adding a borax solution, which creates crosslinks between chains. In this activity, some interesting properties of the slime are investigated.



What to record

Results of the tests.

What to do

1. Collect 40 cm^3 of polyvinyl alcohol solution in a disposable cup containing a spatula.
2. If desired add one drop of food colour or fluoroscein dye to the solution. Stir well.
3. Measure 10 cm^3 of borax solution and add this to the polyvinyl alcohol solution. Stir vigorously until gelling is complete.
4. Remove the slime from the cup and pat and knead it thoroughly to completely mix the contents. Roll the slime around in your hand, gently squeezing the material to remove air bubbles at the same time.

Safety

Wear eye protection.

Questions

Test the properties of your slime

1. Pull slowly – what happens?
2. Pull sharply and quickly – what happens?
3. Roll the slime into a ball and drop it on the bench – what happens?
4. Place a small bit on the bench and hit it with your hand – what happens?
5. Write your name on a piece of paper with a water based felt tip pen. Place the slime on top, press firmly, then lift up slime. What happened to the writing? To the slime? Try the same thing using a spirit-based pen. Does this show the same effect?

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6. Place a small piece of your slime on a watch glass or petri dish. Add dilute hydrochloric acid dropwise, stirring well after each drop. When a change is noticed record the number of drops added and your observations.
7. Now add dilute sodium hydroxide solution dropwise to the same sample used in 6 stirring after each drop. When a change is noticed record your observations. Can the whole process be repeated with tests 6 and 7? Try it!