Polymer Activity from the:

Slimes and Gluep

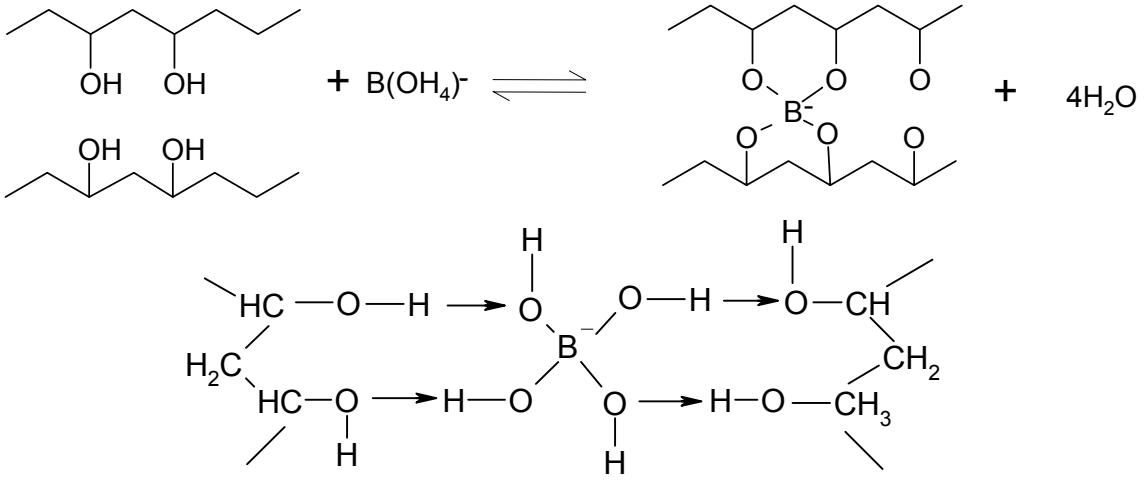
Grades: K-2 and 3-5 and 6-8 and 9-12

Science Standards: Content Standard B: Physical Science;

Background for the teacher and/or advanced students:

Poly(vinyl alcohol) (PVA) is an addition polymer where -CH_2-CHOH- is repeated several thousand times. The alcohol group -OH- is located on alternating carbon atoms. The long chains make the liquid very viscous or thick. There are hydrogen bonds between the chains which gives the polymer its water soluble property. PVA can be added to other polymer chains to give the water absorbing capability to the product like in sweat sponges or in laundry bags for handling contaminated medical supplies.

In the making of PVA balls, the cross-linking ion is borate from sodium tetraborate decahydrate or borax. There are two types of cross-linking possible:

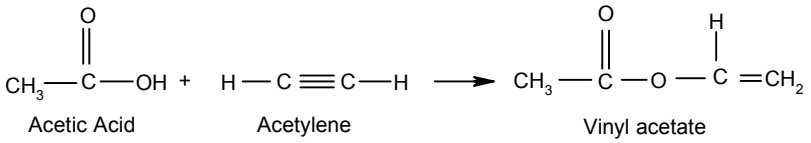


Water molecules occupy most of the space within the three-dimensional structure of these balls. The balls will dry-out if left in the air.

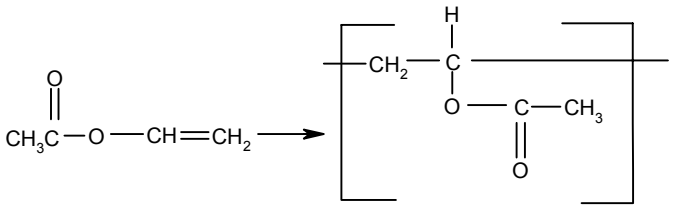
Amazing Bags

A laundry bag containing dirty linens from a hospital room is tossed into the washing machine. The closed bag with the linens went into the machine! Why would someone do that? Everyone knows that you can't expect your shirt to come clean if you wad it into a bag and toss the bag into the washing machine. Hospitals are now using dissolvable plastic bags. This plastic is strong and airtight under room conditions but dissolves in hot water. Everyone is familiar with polyethylene sandwich bags and trash bags. Poly(vinyl chloride) films are used to make shower curtains and umbrellas. These polymers don't dissolve in water.

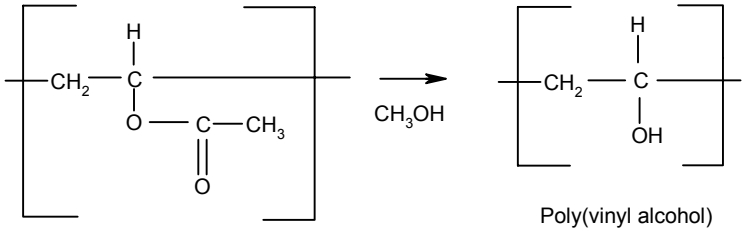
The water soluble bags are made of poly(vinyl alcohol), PVA. This is the same polymer used in making balls in the accompanying laboratory. The chemistry needed to make PVA is below:



Vinyl acetate is made in the first step by reacting acetic acid and acetylene. By free radical polymerization, chain-like molecules of poly(vinyl acetate) are formed.



The poly(vinyl acetate) is reacted with methyl alcohol. The acetate groups on the polymer chain are replaced with -OH- groups to form poly(vinyl alcohol). The hydroxyl, -OH-, groups are hydrogen bonded to water molecules in an aequeous solution which renders the polymer soluble in water.



Poly(vinyl alcohol) is used in other ways other than making water soluble bags. The thread is used in some fabric weaves so that when the material is washed, an open structure is obtained. PVA films are made with varying solubilities. If nearly all the acetate groups are replaced by alcohol groups, the resulting film is soluble in hot water. If some acetate groups remain, the polymer will dissolve in cold or hot water. The residue acetate groups weaken the hydrogen bonding of the polymer to water molecules. All these films are insoluble in gasoline, grease and oils. PVA films are used for dye packages and detergent packages that dissolve in water. Highly concentrated pesticides and herbicides are packaged in PVA.

Instructions for Making PVA Slime

Materials:

20 mL 4% polyvinyl alcohol (PVA)
5 mL 4% sodium tetraborate
zipper-type plastic bag
10 mL graduated cylinder
food coloring
paper cup
spoon or stick
50 mL graduated cylinder
goggles

Procedure:

1. Measure out 20 mL of 4% PVA using the 50 mL graduated cylinder. Pour 20 mL of 4% PVA into a cup.

2. Add one drop of food coloring.
3. Using the 10 mL graduated cylinder, measure and pour 5 mL of 4% sodium tetraborate solution into the cup and stir.
4. Once the slime forms, remove it from the cup and knead it with your hands.
5. Store the slime in a plastic bag.

Poly(vinyl alcohol), PVA, can be purchased in powder form or in 4% solution form. If you make your own 4 % solution (4 grams in 96 mL of water). Follow the steps for 8% but change the proportions.
(This product is nontoxic and nonstaining but it may stick to carpeting and upholstery. If it becomes moldy, dispose of it in the trash.)

Instructions for Making PVA Film Slime

Materials:

Part of a dissolvable poly(vinyl alcohol) bag - Cut a 10 cm x 15 cm piece of the bag which includes the front and back or two layers thick, or 1 g (each bag is about 24 g or 52 cm x 58 cm and this will make about 18 pieces) OR Teacher may dissolve the whole bag in 500 mL hot water (70° C) to make about a 4% PVA solution (The solution must be at room temperature for the cross-linking to work.)

food coloring
5 mL 4% sodium tetraborate solution (Borax)
beaker and spoon
goggles
scissors
hot plate
thermometer
plastic bag

Procedure for students:

1. Cut the PVA piece (10cm x 15cm) into smaller pieces about 1-2 square centimeters each.
2. Using a hot plate, heat 20 mL of tap water, in a beaker, to about 70° C.
3. Add the pieces of PVA to the hot water and stir.
4. Let the solution cool to room temperature.
5. Add one drop of food coloring.
6. Add 5 mL 4% sodium tetraborate solution (Borax) and stir.
7. Once the slime forms, remove it from the beaker and knead it with your hands.
8. Store the slime in a plastic bag.
9. Clean your beaker and spoon with water.

If the slime feels sticky, add a little more sodium tetraborate solution. If the slime is very wet and runny, knead it and excess sodium tetraborate will be absorbed. The dissolvable PVA bags may be purchased from Educational Innovations or you may be able to get them at a local hospital.
(This product is nontoxic and nonstaining but it may stick to carpeting and upholstery. If it becomes moldy, dispose of it in the trash.)

Instructions for Making Gluep

(Gluep is similar to slime but is made from glue or poly(vinyl acetate).)

Materials:

20 mL of diluted Elmer's® Glue-All (10 mL glue mixed with 10 mL water)
(Not all white glues work as well as Elmer's.)
1 drop of food coloring
5 mL 4% sodium tetraborate solution (borax)
cup, spoon and plastic bag
goggles

Procedure:

1. Place 20 mL of the diluted Elmer's® Glue-All in a paper cup
2. Add one drop of food coloring and mix with a spoon
3. Add 5 mL 4% sodium tetraborate solution and stir.
4. Once the Gluep forms, remove it from the cup and knead it with your hands.
5. Store the Gluep in a plastic bag.

NOTE: It is also possible to mix all the ingredients in a baggie, knead and it is crosslinked. (This product is nontoxic and nonstaining but it may stick to carpeting and upholstery. If it becomes moldy, dispose of it in the trash.)

Instructions for Making Starch Packing Peanut Slime

Note: Not all starch packing peanuts will make slime. You have to try them and find out which ones contain poly(vinyl alcohol).

Materials:

Starch packing peanuts
1 drop of food coloring
4% sodium tetraborate solution (borax)
cup, spoon and plastic bag

Procedure:

1. Place about 5 mL of water in a cup. Add several (6-8) starch packing peanuts and stir to dissolve. This will form a thick bubbly mass. Add more peanuts until it is thick and gooey. (The bubbles are carbon dioxide being released.)
2. Add one drop of food coloring.
3. Add 1 mL of 4% sodium tetraborate solution (borax) and stir.
4. If the mixture starts to gel, you have your slime. If it does not gel, the peanuts do not contain PVA for cross-linking.
5. Store in a plastic bag.

Note: These peanuts are an easy way to make a starch solution that will test positive for starch with iodine by turning blue-black.

PVA Ball Kit

This kit is purchased from Oriental Trading Company (1-800-246-8400). Each kit (#12/9) makes two balls from a four percent hydrolyzed PVA powder. Follow the directions on the card. As of 7/97, the price was $7.20 per dozen packages.

Teacher Demonstration

Cross Linking

Purchase about 5 to 6 yards for key-chain chain from a hardware store or craft store. This chain is about $.35 per foot and is magnetic. Do not buy the bathroom chain which is more expensive and nonmagnetic. Hold up the mass of chain to represent the polymer chains in poly(vinyl alcohol). This liquid flows and is rather viscous. To demonstrate cross-linking, add several small strong magnets to the chain. (The sections from a cow magnet work well!) Squeeze the bundle and then pull gently to demonstrate the flowing nature of "slimes".

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