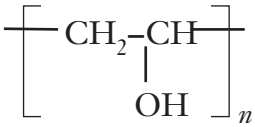
Polyvinyl Alcohol Prep and Activities

Introduction

Polyvinyl alcohol (PVA) is the world's largest volume, synthetic, water soluble polymer. PVA is nonhazardous and is used in many adhesives, films and elastomers. Its most popular use in schools is in the preparation of "slime." PVA is a polymer with a repeating vinyl alcohol unit and its molecular weight can range from 25,000 to 300,000.



Preparation of a 4% Polyvinyl Alcohol Solution

There are two methods for preparing a 4% aqueous solution of polyvinyl alcohol, the conventional heating method and the microwave heating method. The microwave method is much easier and less time consuming. Flinn Scientific also sells 4% polyvinyl alcohol solutions. Once the 4% polyvinyl alcohol solution is made it will last 6 to 8 weeks. It is a good idea to store this solution in a refrigerator, as it will support bacteria growth. (Flinn Scientific adds a preservative to its solutions.) It is recommended that tap water be used when making the polyvinyl alcohol solution. Bacteria will grow much faster in a polyvinyl alcohol solution that contains distilled water. Polyvinyl alcohol and its solutions are considered non-toxic.

Microwave Method

Weigh 40 grams of polyvinyl alcohol into a 1-L borosilicate glass beaker. Fill the beaker to the 1-L mark with hot tap water; stir. Cover with microwaveable plastic wrap. Microwave on high for about 3 minutes; stir and heat for an additional 3 minutes. Stir and heat for another 2 to 3 minutes. Repeat this process one more time, if necessary. Using short increments of time between stirring will produce the best results. Time will vary widely depending on the power of your microwave. With a clean spatula, remove the polyvinyl alcohol film lying on top of the solution. Allow the solution to cool before use.

Conventional Method

It is not easy to make aqueous solutions of polyvinyl alcohol using the conventional method. Polymer behavior is tricky and preparing the solution requires patience.

Heat 1 liter of tap water to 88–90 °C (194 °F) or just below the boiling point of water. Once the water is heated, lightly sprinkle the polyvinyl alcohol into the water while stirring continuously (a magnetic stirrer/hot plate works beautifully to heat and stir the solution). It's important that the polyvinyl alcohol be added **lightly** and **slowly** since each grain of polyvinyl alcohol must be individually "wetted" for it to go into solution. Remember, add the polyvinyl alcohol slowly while continuously stirring. Failure to stir during the addition of the polyvinyl alcohol will result in a gooey mass of wet polymer that sticks together, settles out, and clings to the wall of the vessel.

Be careful to avoid overheating your solution. Overheating will cause water evaporation and a thick film will form on top of the solution. Also, very high heat may interfere with the hydrogen bonding interaction which is occurring between the polyvinyl alcohol and the water.

It will easily take 20 minutes to make the 1-L solution, so please be patient. The completed polyvinyl alcohol solution should be clear, nearly colorless, and rather viscous (a semi-thick liquid).

The Preparation of Slime

Materials

Polyvinyl alcohol, 4% solution, 50 mL

Sodium borate, 4% saturated solution, $Na_2B_4O_7 \cdot 10H_2O$, 5 mL

Graduated cylinder, 10-mL

Graduated cylinder, 50-mL

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Disposable cup
Food coloring (optional)
Wooden stick

Safety Precautions

Students should be warned not to ingest the material and to use it only for the purposes intended. Do not allow slime to remain on clothing, upholstery, carpet, or wood surfaces. The slime will stain many surfaces. Clean up any slime as soon as possible. Wear chemical splash goggles. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Place 50 mL of 4% polyvinyl alcohol solution into a disposable cup. Add a couple drops of food coloring, if desired, and stir with a wooden stick.
2. Pour 5 mL of saturated sodium borate solution (4%) into the cup while stirring (saturated sodium borate is about 4 g per 100 mL of water). The mixture will gel almost immediately but keep stirring until smooth.
3. To observe the properties of slime, knead it into a ball. Hold a small part of the ball and watch it stretch without breaking. Try stretching the slime quickly and see how it will break under these conditions. Slime will also pick up ink from paper. Have the students draw a picture or write their name backwards with a water soluble marker. Press the ball of slime onto the paper for only a split second. The design will be transfered to the slime. (The slime will stick to the paper if left on too long.)
4. The slime will last two days to a week. Store it in an air tight, plastic sandwich bag. When the slime starts to mold, dispose of it in a waste container.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Slime, polyvinyl alcohol solution, cups, and wooden sticks may be placed in the trash. Leftover sodium borate solution may be saved for later use or rinsed down the drain with water according to Flinn Suggested Disposal Method #26b.

Reference

Shakhashiri, B. Z. *Chemical Demonstrations;* University of Wisconsin: Madison, WI, 1989; Vol. 3, p 326.

Polyvinyl Alcohol Rope

Introduction

Ropes of polyvinyl alcohol can be produced from aqueous solutions of polyvinyl alcohol and acetone. Polyvinyl alcohol is soluble in water but insoluble in acetone. Layering acetone over a 4% solution of polyvinyl alcohol creates a white interface of fibers which can be pulled upwards through the acetone to produce a polyvinyl alcohol rope. This demonstration is similar to the nylon demonstration but it is less expensive and uses less hazardous materials.

Materials

Acetone, 30 mL
Aluminum foil, ~30 × 30 cm
Polyvinyl alcohol, 4% solution, 50 mL
Food coloring (optional)
Beaker, 150-mL
Paper towels
Tweezers or forceps

Safety Precautions

Acetone is flammable and a dangerous fire risk, toxic by ingestion and inhalation, and a skin and eye irritant. Due to the amount of acetone used, adequate ventilation is necessary and a fume hood is recommended. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Pour 50 mL of 4% polyvinyl alcohol solution into a 150-mL beaker. *Optional:* Add a drop or two of food coloring (green will be a big hit!) and stir.
2. Carefully pour 30 to 40 mL of acetone on top of the polyvinyl alcohol solution. It helps if the beaker containing polyvinyl alcohol is slightly tipped and the acetone is poured along the side of the beaker from another beaker or graduated cylinder. A white interface of polyvinyl alcohol will immediately appear between the two liquids.
3. Using a pair of tweezers or forceps, pick up the interface layer and slowly pull it straight upwards from the beaker. A strand of polyvinyl alcohol rope, 30 to 40 cm in length, can easily be pulled out. Longer strands are possible if after 30 to 40 cm, a second pair of tweezers (or gloved hand) pinches the polyvinyl alcohol rope near the solution and continues to pull. The first section of polyvinyl alcohol rope can then be doubled over.
4. More ropes can be pulled out of the polyvinyl alcohol solution. Slightly stirring the polyvinyl alcohol solution helps. The first rope is usually the longest and most impressive. Lay the ropes out on paper towels or aluminum foil in a fume hood overnight to dry.
5. After drying overnight, additional demonstrations of polyvinyl alcohol as a polymer are possible. For example, polyvinyl alcohol is flexible but inelastic when dry; however, if dipped briefly in water, it becomes elastic.
6. Alternative demonstration: Squirting aqueous polyvinyl alcohol solutions into acetone precipitates polyvinyl alcohol as a fibrous mass. These fiber balls can be removed with forceps and dried overnight.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The acetone can be poured off the polyvinyl alcohol solution and evaporated in a fume hood according to Flinn Suggested Disposal Method #18a. The aqueous solutions can be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Form and function

Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standard E: Science and Technology; uses of polymers in industry
Content Standard F: Science in Personal and Social Perspectives; science and technology in society

Content Standards: Grades 9–12
Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions
Content Standard E: Science and Technology
Content Standard F: Science in Personal and Social Perspectives; science and technology in local, national, and global challenges

Reference

Sherman, M. C. *J. Chem. Ed.*, **1992,** *69*, 883.

Materials for *Polyvinyl Alcohol Prep and Activities* are available from Flinn Scientific, Inc.

Catalog No.	Description
A0009	Acetone, 500 mL
P0209	Polyvinyl alcohol solution, 500 mL
P0210	Polyvinyl alcohol solution, 1 L
P0153	Polyvinyl alcohol, 100 g
P0154	Polyvinyl alcohol, 500 g
S0334	Sodium borate, tetra, 100 g
V0003	Food coloring, set of 4
AP7236	Magnetic Stirrer/Hot Plate, 4''× 4''

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.