POLYVINYL ALCOHOL SLIME

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Slime, a product of the Mattel Toy Corporation, was originally marketed during the time period from 1976 to about 1979, then later, in the 1980's, as Masters of the Universe Slime, and, again, as Nickelodeon Green Slime. Slime-type materials have also been available as Weird Ball Sludge® (in Lucky Yellow, Putrid Purple, and Ghastly Green colors) from Mel Appel Enterprises, Inc., as purple Ecto-Plazm® from Kenner Parker Toys Inc, as Living Nightmare® Body Fluids from Fun World, as Teenage Mutant Ninja Turtles Retromutagen Ooze from Playmates Toys, as Toxic Crusaders™ Toxic Waste™ from Playmate Toys, as Dinosaur Ooze™ from Imperial Toys, and other similar materials. Slime-type materials continue to be available in many different names and can be found in many toy stores.

Slime was described by Dr. Maki Papavasiliou, of the Mattel Materials Laboratory, as a reversible cross-linking gel made from Guar gum, a vegetable gum used as a protective colloid, stabilizer, and thickening agent for foods, cosmetics, and lotions. The cross-linking is accomplished by the addition of borax, $Na_2B_4O_7 \cdot 10H_2O$ (sodium tetraborate).

Slime is a non-Newtonian fluid that is dilatant, that is, under stress, the material dilates or expands. Other stress-thickening materials are quicksand, wet sand on the beach, some printer's inks, starch solutions, and Silly Putty. Dilatant materials tend to exhibit some unusual properties.

a) Under low stress, such as slowly pulling on the material, it will flow and stretch. If careful, you can form a thin film.
b) Pull sharply (high stress) and the material breaks.
c) Pour the material from its container then tip the container upward slightly, the gel will self siphon.
d) Put a small amount of the material on a table top and hit it with your hand, there is no splashing or splattering.
e) Throw a small piece onto a hard surface, it will bounce slightly.
f) Stuff the material through a tube, die swell occurs as it emerges.

This investigation uses a substance called polyvinyl alcohol (See Figure 1) in place of guar gum since solutions can be prepared in advance and weighing of materials is not required. Polyvinyl alcohol is used as a thickener, stabilizer, and binder in cosmetics, paper cloth, films, cements and mortars. Polyvinyl alcohol solution dries to leave a thin plastic film that is finding use in packaging materials. This film, if left in the environment will break down rather than persist as some plastics do requiring clean-up.

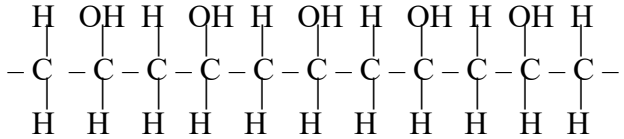

Figure 1. The structure of polyvinyl alcohol

The polyvinyl alcohol is cross-linked using borax, $Na_2B_4O_7 \cdot 10H_2O$ (sodium tetraborate). . (See Figure 2)

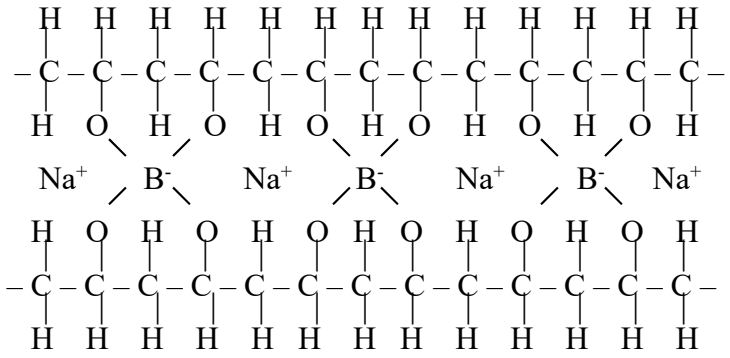

Figure 2. Crosslinked polyvinyl alcohol gel

PROCEDURE: Polyvinyl Alcohol Slime

1. Materials needed:

paper cup, 5 oz
stirring rod
Polyvinyl alcohol, 4% solution in water. (See "Preparation of Solutions" at the end of this investigation.)
Borax (sodium tetraborate decahydrate), $Na_2B_4O_7 \cdot 10H_20$, 4% solution, weight in water.
Food color to color the Slime (optional)
Plastic bag to store the Slime (zip-lock type or bag with twist tie)
Felt-tip pen
Paper

2. Safety Precautions:

Wear safety goggles or glasses at all times in the laboratory.

There are no hazards associated with the polyvinyl alcohol.

Sodium borate (borax) is toxic by ingestion. Take care that this material is not placed in the mouth.

Take care to keep the chemicals and the Slime away from your clothes or cloth covered furniture as they may produce permanent stains.

The Slime will get dirty from handling and may become moldy after several days. When this occurs, the Slime should be discarded

3. Disposal and Storage:

Store the Slime in an air-tight container, such as a zip-lock bag or plastic bag with a twist-tie. Dip the slime in some water before storing it to keep it from drying out.

Dispose of any Slime in the trash. Do not put it down the drain as it will clog the drain.

4. Experimental Procedure:

Preparation:

Obtain 20 mL of 4% polyvinyl alcohol solution in a paper cup and a stirring rod. Examine the solution. Does it have any odor? Is it sticky? What happens when a small amount dries on your fingers?

If desired, one or two drops of food color can be added to the polyvinyl alcohol solution. Stir the mixture.

Measure 5 mL of 4% borax solution. Pour the borax solution into the cup of polyvinyl alcohol and stir well. Describe what happens.

Remove the material from the cup and knead it in your hand. The material will become firm and lose some of its stickiness.

Testing your Slime:

Test the properties of the "slime".

a) Can you stretch it if you pull the Slime slowly?

b) What happens when you pull the Slime hard?

c) Roll a piece of Slime into a ball and drop it. What happens?

d) Place a small piece of Slime on the table top. Hit it with your hand. What happens?

e) Write your name on a piece of paper with a felt-tip pen. Place the Slime on your name, the lift it up. Did anything happen? Can you explain why?

This investigation using polyvinyl alcohol is based on Weill, David R. III, "Colloids, Slime and Some Non-Newtonian Fluids: Some Demonstrations", Sixth International Conference on Chemical Education, University of Maryland, August, 1981. (David Weill, deceased, was a distinguished teacher at Shady Side Academy, 423 Fox Chapel Road, Pittsburgh, PA 15238.)

PROCEDURE: Elmer's Gel Glue Slime

1. Materials needed:

paper cup, 5 oz
stirring rod
Elmer's Gel Glue (This is the blue colored glue. It is made using polyvinyl alcohol.)
Borax (sodium tetraborate decahydrate), $Na_2B_4O_7 \cdot 10H_20$, 4% solution, weight in water.
Food color to color the Slime (optional)
Plastic bag to store the Slime (zip-lock type or bag with twist tie)

2. Safety Precautions:

Wear safety goggles or glasses at all times in the laboratory.

There are no hazards associated with Elmer's Gel Glue.

Sodium borate (borax) is toxic by ingestion. Take care that this material is not placed in the mouth.

Take care to keep the chemicals and the Slime away from your clothes or cloth covered furniture as they may produce permanent stains.

The Slime will get dirty from handling and may become moldy after several days. When this occurs, the Slime should be discarded

3. Disposal and Storage:

Store the Slime in an air-tight container, such as a zip-lock bag or plastic bag with a twist-tie. Dip the slime in some water before storing it to keep it from drying out.

Dispose of any Slime in the trash. Do not put it down the drain as it will clog the drain.

4. Experimental Procedure:

Obtain 20 mL Elmer's Gel Glue in a paper cup. If it is too thick, up to 10 mL of water can be added to the glue, the stir to mix. Examine the glue solution. Does it have any odor? Is it sticky? What happens when a small amount dries on your fingers?

If desired, one or two drops of food color can be added to the glue solution. Stir the mixture.

Measure 5 mL of 4% borax solution. Pour the borax solution into the cup of polyvinyl alcohol and stir well. Describe what happens.

Remove the material from the cup and knead it in your hand. The material will become firm and lose some of its stickiness.

Test the properties of the "slime" using the procedure on the preceding page..

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PREPARATION OF SOLUTIONS

1. Preparation of Polyvinyl Alcohol Solution

Materials Needed

polyvinyl alcohol, 99-100% hydrolyzed. (Available from Flinn Scientific Inc.)
water, (distilled or deionized preferred but not essential)
1000 mL (or larger) flask or beaker (a pot can be used - glass is preferred) Alternative: A heatproof plastic container
heat source (hot plate, gas or electric range) Alternative: A microwave oven
stirring rod
1-liter (or larger) plastic bottle to hold solution
aluminum foil
labels for bottle

To prepare one liter of 4% polyvinyl alcohol solution:

Method 1: Using a conventional heat source

Measure 960 mL of water into a large flask or beaker (or pot).

Measure 40 grams of polyvinyl alcohol.

Add the polyvinyl alcohol to the water slowly, with stirring.

Heat the mixture, stirring occasionally, until a clear solution is obtained. Avoid boiling the solution. Remove from heat, cover with aluminum foil, and allow the solution to cool.

Pour the solution into a properly labeled bottle and seal. The solution can be stored indefinitely.

Method 2: Using a microwave oven (This is the preferred method for preparing the solution.)

Measure 960 mL of water into a large beaker or heatproof plastic container.

Measure 40 grams of polyvinyl alcohol.

Add the polyvinyl alcohol to the water slowly, with stirring.

Place in a microwave oven. Heat the mixture, on high, for one minute. Open the oven and stir the mixture. Heat for one minute, open the oven and stir the mixture. Continue heating for one minute intervals, stirring after each heating cycle, until a clear solution is obtained. Avoid boiling the solution. Remove from thre oven, cover with aluminum foil, and allow the solution to cool.

Pour the solution into a properly labeled bottle and seal. The solution can be stored indefinitely.

2. Preparation of Borax Solution

Materials Needed

borax (sodium tetraborate decahydrate), $Na_2B_4O_7\ 10H_20$. (20 Mule Team Borax or equivalent)
water, (distilled or deionized preferred but not essential)
1-liter plastic bottle to hold solution
label for bottle

To prepare one liter of 4% borax solution:

Measure 960 mL of water into a 1-liter bottle

Measure 40 grams of borax.

Add the borax to the water. Close the bottle and shake. The solution can be stored indefinitely.