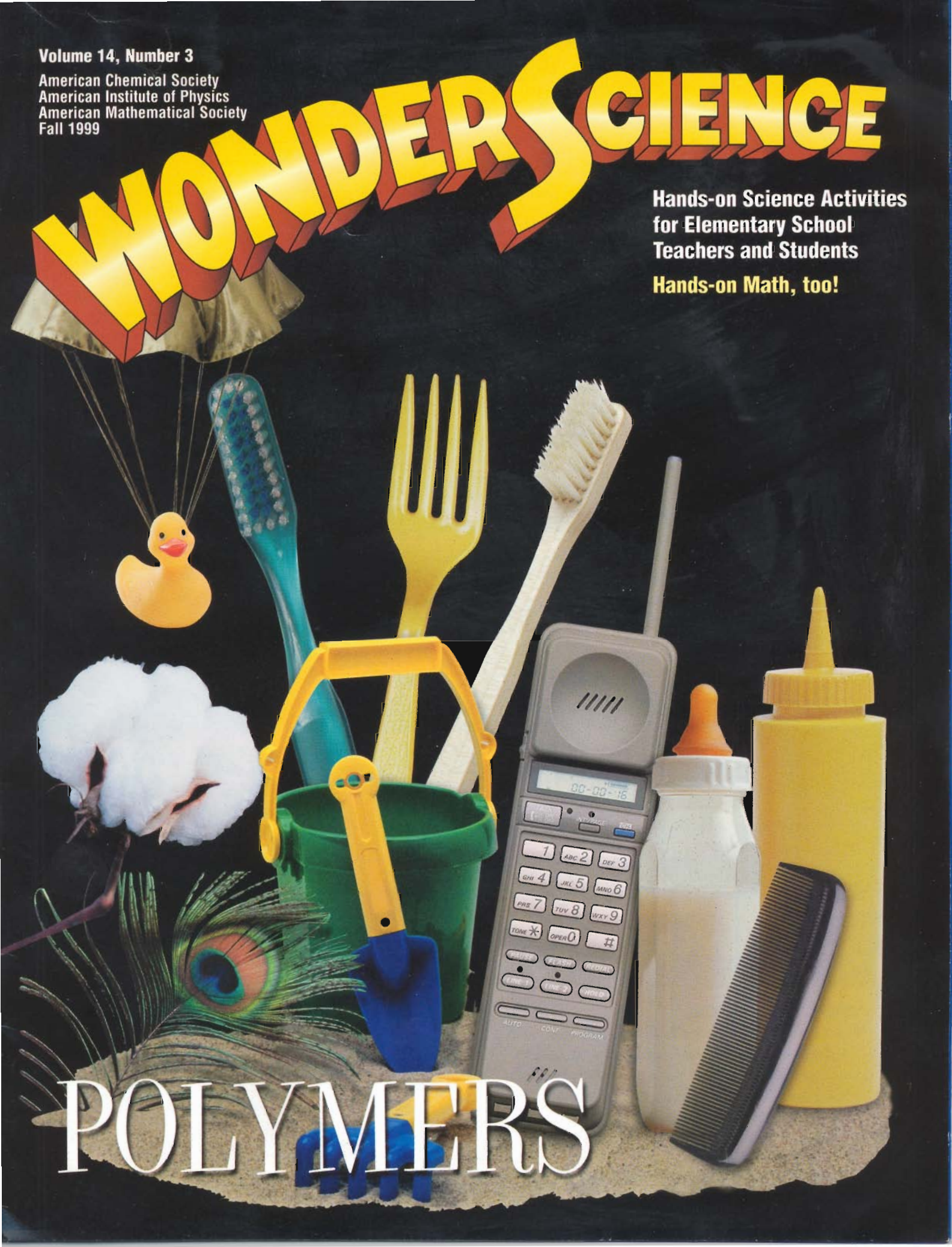
Volume 14, Number 3
American Chemical Society
American Institute of Physics
American Mathematical Society
Fall 1999

WONDERSCIENCE

Hands-on Science Activities for Elementary School Teachers and Students

Hands-on Math, too!



POLYMERS

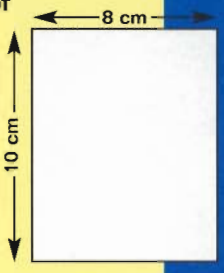
YOU WILL NEED:

- **plastic wrap**
- **plastic shopping bag**
- **plastic film insert**
- **scissors**
- **3 cups** (plastic or paper)
- **water**
- **paper towel**

A Plastic Film Festival!

TEACHER PREPARATION

Cut each type of plastic into pieces that are about 8 cm × 10 cm. Each group should get 1 piece of each type of plastic.

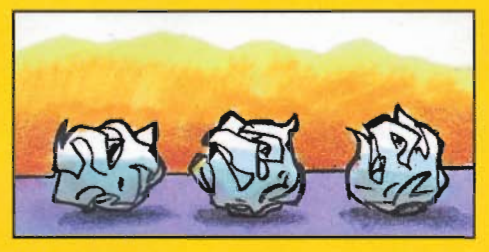


Polymers are chemicals that make up lots of common and very useful materials. One important material made from polymers is plastic. One of the great things about plastic is that it can be molded into almost any shape. In this activity, you can test different plastics that have been molded into very thin films. Be prepared for some surprises!

Make a large chart like the one shown on page 3 or use the one from the Student Activity Sheet. You will use the chart to record your observations about the plastics for each test.

CRUMPLE/WRINKLE TEST

Crumple each piece of plastic into a ball as small as you can make it. Let the pieces uncrumple. Record your observations for each plastic.



STRETCH TEST

While holding the plastic firmly, pull it until it stretches. Try to stretch it without tearing it. Now hold it in a different place, and pull in a different direction until it stretches. Record your observations.

SEE-THROUGH TEST

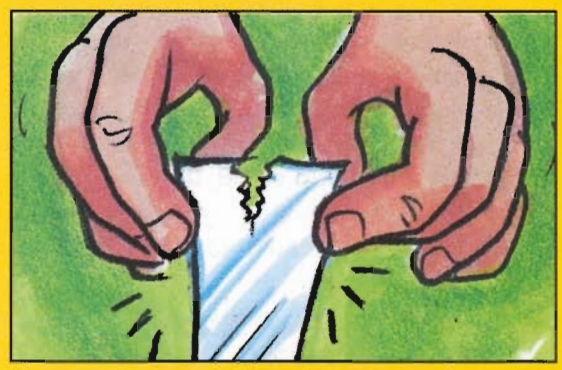
Hold each piece up and look through it toward a light in the room. How well were you able to see through it? Record your observations. Put each piece down on a page from a book or magazine. How well were you able to see through it? Record your observations.

STICK-TO-ITSELF TEST

Fold the piece of plastic over on itself and rub the two halves together. Did you notice any difference between the way the different plastics stuck to themselves? Record your observations.

TEAR TEST

At this point, your pieces of plastic are a little beaten-up, but you can still do the tear test on them. Use your thumb and index finger from both hands to tightly grasp the edge of the plastic as shown. Tear each plastic and compare what you notice about each one. Record your observations.



WATER TEST

Place a paper towel on your work surface. Fill three cups about half-full with water. Dip each piece of plastic into its own cup so that the plastic goes under the water. Take the pieces out and put them on the paper towel. What do you notice about how the water and the plastic look? Record your observations.

	Crumple/ Wrinkle test	Stretch test	See-through test	Stick-to-itself test	Tear test	Water test
Plastic wrap						
Shopping bag						
Film insert						

Pondering Polymers

A polymer is a very long chemical made up of repeating little chemical units all hooked together in a very long chain. Polymers are found almost everywhere in nature. Some natural polymers are the **proteins** that make up hair, feathers, fur, cartilage, beaks, nails, and horns. Another natural polymer, called **cellulose**, makes up wood, leaves, and other plant parts. Cotton, starch, silk, and rubber (from rubber trees) are also made of natural polymers.

There are also polymers made in factories, or **synthetic** polymers. The most common synthetic polymer is plastic. The great thing about plastics is that they are lightweight, can be rigid or flexible, can be molded into almost any shape, and can last a very long time. This quality is a problem when it comes to the disposal of plastics. Because they do not break down in nature, plastics take up a lot of room in landfills. But these days, plastics are being recycled more and more to save our resources and to reduce the amount of plastic in landfills.

In "A Plastic Film Festival," you saw that the different plastic films had different characteristics. The plastic included in your *Wonder-Science* is made of a polymer called **polyvinyl alcohol**. This plastic film is very unusual because it dissolves in water. Dissolving plastic film is used to package substances in exact amounts to be dissolved in water. The entire packet can simply be placed in the right amount of water and be mixed up and ready to go! The plastic is also used to make hospital laundry bags. Laundry is placed in the bag, which is then sealed and thrown right in the washing machine, bag and all!

In "Goop To Go," you used Elmer's® glue and laundry detergent to make a polymer. Elmer's glue has its own polymer already in it called **polyvinyl acetate**. Like other polymers, polyvinyl acetate is a long chain. These strands of polyvinyl acetate slide past each other as the glue flows. A chemical in Tide® is able to connect the strands together, forming a polymer with different characteristics. This new polymer will be soft or stiff based on the amounts of glue, water, and laundry detergent you use. In the glue and liquid starch polymer, a chemical in the starch solution binds the polyvinyl acetate molecules together.

In "Diapers—The Inside Story," you looked at a polymer made up of granules found inside disposable diapers. This polymer is called **sodium polyacrylate**. This is called a super-absorbent polymer because it can absorb hundreds of times its weight in water. After water is absorbed, the polymer changes from a powder to a gel. Exactly how the water gets absorbed by this polymer to create a gel is not completely understood. One thing we know is that salt will cause the gel to become a liquid. Try sprinkling a little salt on the gel and stirring to see what happens.

In the last activity, you should be able to poke a pencil all the way through a plastic bag of water and cause no leaks. Can you think of how the long, flexible chains of polymers in the plastic bag might work to allow you to do this?

Dissolving plastic is provided by Chris Craft Industrial Products.

ILLUSTRATION BY STEVE MCENTEE

WONDERSCIENCE Teacher's Guide

Polymers

Welcome to your *WonderScience* magazine on polymers. Plastic, rubber, cellulose (which makes up plant roots, stems, and leaves), proteins, DNA, and synthetic fibers such as polyesters, are all polymers. A polymer is a long chain of repeating molecules. The characteristics of the polymer depend upon the molecules of which it is composed, how they are bonded to each other, and the length of the chain. Your *WonderScience* focuses on the observable characteristics of a few different polymers but does not try to explain these characteristics on the molecular level. As usual, most activities concentrate on the process of experimenting with materials to learn about their properties.

This Issue:

Polymers

Pages 2–3

A Plastic Film Festival!

You could begin the activity by asking students to name some of the qualities of the very familiar plastic film used in plastic grocery bags, sandwich bags, and plastic wrap. You could hand out samples of the three types of plastic and see if students can come up with their own tests to compare the plastics. We suggest six different tests on pages 2–3, but students may think of others. As students perform the different tests, be sure that they record their observations accurately and completely so they can report them to the rest of the class.

We have included a special piece of plastic in your *WonderScience*. It is called polyvinyl alcohol. The plastic has some interesting characteristics when compared to the other plastics in the first five tests, but its uniqueness is revealed in the last test using water. When polyvinyl alcohol is placed in water, it will dissolve. Ask students for possible uses of a thin film that dissolves in water. Some of its uses are discussed on page 4.

Page 5

Goop To Go!

In "Goop To Go!", students make two different polymers. One is made of glue, water, and laundry detergent; the other is made from glue and liquid starch. The laundry detergent that we used was Tide without added bleach. The kind with bleach might work, but we did not try it. You might want to try different laundry detergents to see if any others work better. For the other polymer, we used liquid starch in a plastic bottle with a screw-on squeeze-trigger sprayer top. You can simply unscrew the sprayer top and pour out the starch solution into cups for students. Do not attempt to use liquid starch in aerosol cans—it will not work. If you cannot find liquid starch, simply make the first polymer from glue, water, and laundry detergent and allow students to vary the concentrations of the ingredients to see if they can make polymers with different characteristics.

Pages 6–7

Diapers—The Inside Story

You can ask students to guess about what makes disposable diapers so absorbent. You could take a disposable diaper, unfold it, and place it in water. When it is full, take it out and pass it around the room. Students will be amazed at how heavy it is and at how much water it must have absorbed.

When students are getting the sodium polyacrylate powder out of the diapers, it may at first seem difficult to separate the powder from the cotton material simply by shaking. After shaking for a while, students should tilt the bag so that the powder moves to one lower corner. Then each student should reach into the bag and move the other diaper material away from the powder, but still keeping

continued on last page

National Science Education Standards

The following National Science Education Standards relate to the activities and information in this issue:

Unifying Concepts and Processes

Evidence consists of observations and data on which to base scientific explanations. Use evidence to help understand interactions and predict changes in natural and observed systems. *Conduct investigations to develop explanations about the behavior of some common polymers. (All activities)*

Science as Inquiry

Conduct a scientific investigation. Develop ability to make systematic observations and identify and control variables. *Students investigate the characteristics of polymers by making and testing their own polymers, as well as through testing some common commercial polymers. (All activities)*

Think critically and logically to make the relationships between evidence and explanations. Review and summarize data, and form a logical argument about the cause-and-effect relationships in the experiment. *Analyze observations from a*

continued on last page

STUDENT ACTIVITY SHEET

NAME _____ **DATE** _____

Pages 2–3: A Plastic Film Festival!

Use the chart below to record your observations for the tests on pages 2 and 3.

	Crumple/ Wrinkle test	Stretch test	See-through test	Stick-to-itself test	Tear test	Water test
Plastic wrap						
Shopping bag						
Film insert						

STUDENT ACTIVITY SHEET

NAME _____ **DATE** _____

Page 5: Goop To Go!

Use the chart to record your observations for the three different polymers that you made on page 5.

	Observations
Polymer I	
Polymer II	
Polymer III	

Pages 6–7: Diapers—The Inside Story

1. On the paper towel without the diaper granules (sodium polyacrylate), how many drops of colored water did it take for the water to travel to the edge of the cup? _____

2. On the paper towel *with* the diaper granules (sodium polyacrylate), how many drops of colored water did it take for the water to travel to the edge of the cup? _____

3. How does the sodium polyacrylate look as water is added to it?

_____

_____

4. What do you think the sodium polyacrylate is doing to the water as water is added to it?

_____

_____

5. In step #10, how many teaspoons of water did your last cup of sodium polyacrylate soak up? _____

6. Now that you see what sodium polyacrylate can do, can you think of any other uses for it aside from its use in diapers?

_____

_____

continued from first page

everything in the bag. The bag should then be resealed and grasped in the middle, keeping the other diaper material separate from the sodium polyacrylate powder. Students should then shake the bag some more, and the powder should fall down into the lower part of the bag.

In the first part of the experiment, it should only take 4–6 drops to reach the cup edge on the paper towel with no sodium polyacrylate. On the paper towel that *does* have the powder, it should take over 100 drops. The volume of the powder should increase as it absorbs water and becomes a gel.

Sodium polyacrylate is sold at gardening stores as a medium for growing plants. It can hold a lot of water and then release it gradually to the plant roots.

Poke But Don't Soak

You could fill a plastic bag with water and hold a sharpened pencil up and ask students what they think will happen if you push the pencil into and then through the bag. After getting their answers, you could hold up an inflated balloon and a long wooden skewer and ask the same question.

When students push the pencil through the bag, very little if any water should leak out. This is due to the flexibility and waterproof qualities of the plastic. The plastic molds around and squeezes against the pencil, making a water-resistant seal. After students have done this activity, you could demonstrate a similar phenomenon with an inflated balloon. Rub a little vegetable or mineral oil along the length of the skewer. Carefully poke through the thick, unexpanded rubber near the knot of the balloon. Then twist the skewer as you move it through the balloon and then poke the skewer through the thickest part at the other end of the balloon.

National Science Education Standards

continued from first page

simple experiment and use that data to develop explanations. (Diapers—The Inside Story, Poke But Don't Soak)

Physical Science

A substance has characteristic properties, all of which are independent of the amount of the sample. *The various properties of polymers are investigated. (All activities)*

Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. *Students combine substances to make their own polymers. (Goop To Go!)*

Science in Personal and Social Perspectives

Human activities can induce hazards through waste disposal. Such activities can accelerate many natural changes. *Develop understanding that the durable nature of some synthetic polymers has created a waste disposal problem. (Pondering Polymers)*

Technology influences society through its products and processes. *Develop understanding of the vast influence polymers have had on society. (Pondering Polymers)*

We want to hear from you!
Please e-mail us with suggestions, comments, and ideas for future issues!
wonderscience@acs.org

Goop To Go!

In "A Plastic Film Festival," you made a solid polymer dissolve using a liquid (water). In this activity, you can combine two liquids to create a polymer that is more solid!

YOU WILL NEED:

- **Elmer's® glue**
- **Tide® powdered laundry detergent**
- **liquid starch** (not aerosol can)
- **paper towels**
- **measuring spoons**
- **water**
- **small plastic cups**
- **straws or spoons** for stirring

POLYMER I

1 Make a chart like the one shown or use the chart in the Student Activity Sheet. Place 1 teaspoon of Elmer's glue and 1 teaspoon of water into a small cup. Stir to mix.

2 Place 1 teaspoon of Tide powdered laundry detergent into a different small cup. Add 1 tablespoon of water. Stir to mix.

3 While stirring the glue–water solution with a straw, your partner should slowly add the Tide–water solution until a white glob forms in the cup. (This may take between half and all of the detergent solution.)

4 Remove the glob and place it on a paper towel. Cover it with another paper towel and press down gently to soak up some of the excess liquid. Pick up the glob and see what it feels like. Does it stretch, wiggle, or bounce? Can it be molded? Record your observations.

	Observations
Polymer I	
Polymer II	
Polymer III	

POLYMER II

1 Place 1 teaspoon of Elmer's glue into a small cup.

2 While stirring with a straw, your partner should slowly add liquid starch until a white glob forms in the cup. (This will probably take between 2 and 3 tablespoons of liquid starch.)

3 Remove the glob and place it on a paper towel. What do you notice about this polymer compared to the first one you made? Take it off the paper towel and move it between your hands. Record your observations.

POLYMER III

The third polymer you make is up to you! Using Elmer's glue, Tide detergent, water, and liquid starch, see if you can come up with a combination that makes a polymer that has characteristics somewhere between Polymer I and Polymer II. Good Luck!

Wash hands after handling materials.

Diapers—

YOU WILL NEED:

- **diaper** (large, disposable, and super-absorbent)
- **zip-closing plastic bag** 1-gallon-sized
- **water**
- **small cup** (paper or plastic)
- **5 cups** (clear plastic)
- **2 rubber bands**
- **paper towel**
- **food coloring**
- **dropper**
- **measuring spoons**

CAUTION:
Sodium polyacrylate will irritate the nasal membranes if inhaled. Avoid eye contact; if it gets into eyes, they will become dry and irritated. Be sure to wash hands after use.

Polymers come in many different forms. In "A Plastic Film Festival," you used a polymer that was made into thin flat film. In "Goop To Go!" you used liquids and came up with a thick putty kind of polymer. These different polymers had different characteristics.

In the following activity, you will use a polymer that is in a powdered form. It has some special characteristics of its own! Let's investigate them.

1 Use a pair of scissors to cut off the paper or plastic edge around the entire diaper. Place the remaining padded middle part of the diaper into the zip-closing plastic bag.

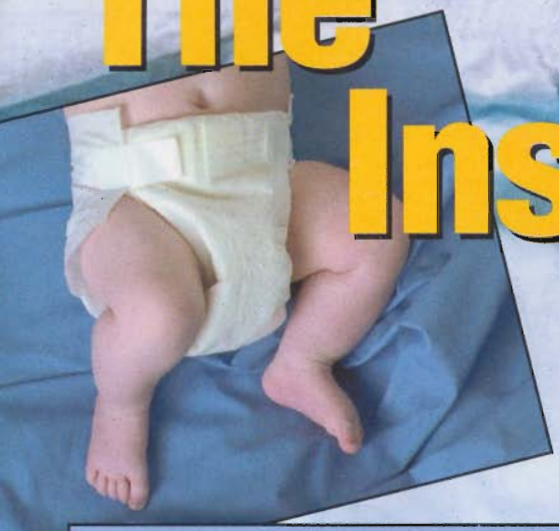
2 Reach into the bag with both hands and separate the cotton, paper, and plastic layers of the diaper. Leave all material in the bag. Seal the bag and shake it for about 1 minute. Look at the bottom of the bag as you tilt it to one side. You should notice white granules collecting in the corner of the bag.

3 Now, without opening the bag, move the cotton, plastic, or other large pieces of material toward the top of the bag. Keep the material up there as you shake the bag again. This will allow the granules to fall down to the bottom without getting picked up by the cotton again.

4 After you have about 1/2 teaspoon of granules in the corner of the bag, slowly open the bag and remove the large pieces of material. Throw them away. Now, carefully pour the granules into a small cup. Wash your hands.

5 Take two empty cups. Cut a paper towel into two pieces that will fit over your cups as shown. Hold the paper towel pieces down over the cups with a rubber band around the rim of each cup.

The Inside Story



6 Place a small amount (about 1/8 teaspoon) of the white granules onto the center of one of the paper towels.

7 Place about 1/4 cup of water into a small cup. Add one drop of food coloring and swirl to mix.

8 Add one drop of the colored water to the center of the paper towel on one cup and one drop to the granules on the other cup. Continue to go back and forth, adding one drop to the paper towel on one cup, and then one drop to the granules on the other.

What do you observe? Which towel is getting wetter? What do the granules appear to be doing? How many drops can you add to the granules before the water spreads to the rim of the cup?

9 Take the rest of your granules and divide them as evenly as you can among three clear plastic cups. Add 1 tablespoon of water to one cup and swirl to mix. Allow the cup to sit still. Watch what happens. What do you observe?

10 Do you think the granules will absorb 2 tablespoons of water? Try it in your next cup and see. How much more do you think it can absorb? Use your last cup to find out!

Poke But Don't Soak

YOU WILL NEED:
zip-closing plastic bag
sharpened pencil
water

The flexibility of plastic makes it useful for many different purposes.

WARNING:
The point of the pencil may be sharp; please handle with care.

1 Fill the plastic bag about 3/4 full of water. Seal the bag. Hold the bag over a sink or bucket or over the ground outside.

2 While you hold the bag, your partner should slowly push the point of the pencil through one side of the plastic bag and into the water. Did any water spill? Don't take the pencil out.

3 Why do you think very little or no water spills? Look closely at the plastic bag surrounding the pencil. How would you describe the way the plastic bag fits around the pencil?

4 Do you think the pencil can go all the way through the water and out the other side of the bag with no water spilling? Ask your partner to slowly push the pencil all the way through the other side of the bag. What happened? Is there anything about long thin polymers that might help explain why the pencil can do this?

ILLUSTRATIONS BY JIM WISNIEWSKI/STEVE EDSEY & SONS UNLESS OTHERWISE INDICATED

James H. Kessler, Editor, ACS; Edward V. Lee, Associate Editor, AIP; Rosalie Dance, Associate Editor, AMS; Peggy Corrigan, Art Director, ACS; Leona Kanaskie, Copy Editor, ACS

WonderScience publishes 4 issues in September and 4 issues in January as a joint effort of the American Chemical Society, 1155 Sixteenth Street, N.W., Washington, DC 20036, and the American Institute of Physics, One Physics Ellipse, College Park, MD 20740; in cooperation with the American Mathematical Society, 201 Charles St., P.O. Box 6248, Providence, RI 02940.

The subscription price is $12.00/eight issues and eight teacher's guides. For additional subscription information, call toll-free **1–800–209–0423** or write to *WonderScience* at the ACS address. Canadian GST Reg. No. 127571347.

The activities described in this booklet are intended for elementary school children under the direct supervision of adults. The American Chemical Society and the American Institute of Physics cannot be responsible for any accidents or injuries that may result from conducting the activities without proper supervision, from not specifically following directions, or from ignoring the cautions contained in the text.

All activities in *WonderScience* have been reviewed for safety by Herb Bryce, Seattle Central Community College, Seattle, WA.

AMERICAN INSTITUTE OF PHYSICS