

LSC/PCCM Polymer Show

Equipment Needed:

Five pounds or so of silly putty

Large Chain (3 ft.)

3 plastic (not clear) cups, numbered 1-3

Sodium Polyacrylate (before the show, fill cup #3 with some sodium polyacrylate)

Instant snow (also Sodium Polyacrylate)

Bottle of colored water

Hoberman sphere toy

3-4 g of Polyethylene Oxide

25 ml of dry anhydrous alcohol

Pitcher of water

2 large beakers

Several smaller pieces of silly putty

Hammer

Items to crush with "Crusher", foam blocks wood block, golf balls, tennis balls, etc.

Script:

Before the show, you have placed some sodium polyacrylate into cup #3. As the audience is sitting, you are rolling a five pound clump of silly putty into a ball.

I am Professor ___ from Princeton University. I study ___ for a living.

Today we are going to be talking about a very important group of chemicals. They're called polymers. Has anyone ever heard of polymers? Polymers are a huge part of your everyday life. First, let's talk about what polymers are, then about where we might see them in our lives. And then, I want to show you all kinds of unusual polymers that do amazing things. Of course, you've all noticed that I am rolling a huge glop of silly putty into a ball. Now, I admit it isn't perfectly round, but I want to bring this around and show it to everyone. Would you all agree it isn't very flat, not perfectly round, but there aren't many flat spots?

Carry the ball of silly putty around so everyone can see it. Then set it on the table.

Now I'm going to set it down here on this table, and we can talk about polymers. Polymers are molecules that are a lot like chains.

Take out the length of chain.

Look at this chain. It is very long, but it's made out of a lot of small metal links. And when we hook these links together, we get a long chain. Polymers are molecules that do something very similar. The word polymer comes from two

Greek words. "Poly" means many and "meros" means part. So a polymer is made out of many parts.

Imagine we start with short molecules. They're called monomers. "Mono" is the Greek word for one. These monomers are like the links. Now we use a chemical reaction, a polymerization reaction, to hook these molecules together. In this way we can make a long molecule, a chain, a polymer. Let me explain in a different way. Can I get some volunteers?

Chain:

Get several volunteers. Each is going to be a monomer.

We're going to pretend that each one of you is a monomer molecule. But if I start a polymerization reaction, suddenly you two need to hold hands. And more people start holding hands.

*Connect your volunteers into two lines of people holding hands.
Save one or two volunteers for cross-links.*

Now, I have created two long polymer molecules. Each monomer in the middle has connected to two other monomers. But, some monomers can connect to more than two other molecules. We could connect two chains. These are called cross-links.

Have a remaining volunteer or two hold onto the arms of people in the two different chains.

If we had lots of people with three or four hands, we could even make our polymers stretch out like a web, with lots of connections in lots of directions. Please, give my volunteers a round of applause.

Sodium Polyacrylate:

Let's talk about some polymers. I have here on my cart three plastic cups. Do you think plastic is a polymer? ... Yes, as a matter of fact it is. Plastics are man-made polymers. Usually we use molecules found in oil or natural gas as our monomers. And we can make all kinds of different plastic polymers out of them. Now, in this bottle I have another chemical. It's water! I know, it's colored. I just put in some food coloring so it would be easier for you to see it. Water is not a polymer. I am going to pour some of this water into one of the cups.

Pour water into cup #1. The sodium polyacrylate is preset in cup #3.

Now, pay close attention to which cup has the water.

Moves the cups about as if playing three card monty. Don't make it too hard. As you ask the following questions point to the cups one at a time, using cup #1 last.

Is the water in this cup? Is it in this cup? How about this cup? Let's see if you're right.

Pick up cup #1 and pour the water out of it into cup #2.

Way to go! You were correct. All right, pay attention again.

Play three card monty again. Sometimes I joke with them and claim that this is how I put myself through college. Point to the cups as you did last time.

Now, is the water in this cup? How about this cup? Or is it this cup? Let's find out.

Pour the water from cup #2 into cup #3 (the one with sodium polyacrylate). This time try to get a bit trickier with the three card monty game. Now, call up three volunteers. Don't let them see the cups.

This time we are going to try this a bit differently. I need three volunteers.

Stand the volunteers in a line. Find out their names. For the first volunteer, point to one of the empty cups.

All right, Nancy, is the water in this cup? Let's see if you're right.

Turn the empty cup upside-down over first volunteer's head. Nothing should come out. For the next volunteer, point to the other empty cup.

I guess that one was empty. Thank you, Nancy. Give her a huge round of applause. Now, Tim, is the water in this cup? Let's see if you're right.

Turn the empty cup upside-down over the second volunteer's head. Nothing should come out. For the last volunteer, point to the remaining cup.

Good news for you, Tim. It was empty! Thank you. Give Tim a round of applause. Now, Joy, things don't look so good for you. Is the water in this last cup? We're going to find out.

Turn this cup upside-down over the volunteer's head. Surprisingly, nothing comes out. The audience is, hopefully, amazed.

I don't know what's going on here either. But let's give Joy a huge round of applause. Thanks for sticking it out, Joy. Let's find out what happened to the water.

Pull the gel out of cup #3.

Before the show, I put some powder into this cup. That powder is called sodium polyacrylate, also called slush powder. Sodium polyacrylate can absorb many times its own weight in water. Take a look at the Hoberman sphere behind you, or the smaller one I have here. Think of sodium polyacrylate as that sphere, and when the water mixes with it, the sphere can fill up with the water. It's almost like it grows and bonds the water inside, holding it tight.

Sodium polyacrylate can be found in something very common, you might even have it in your house. Any ideas?

Let the volunteers guess. You may have to give them hints. Tell them it isn't a food. Ask them if they have younger brothers or sisters. Much younger, maybe even babies.

That's right! Sodium polyacrylate is inside of disposable diapers. It helps keep the moisture away from babies.

Diapers aren't the only places we use polymers. Can anyone think of anything else that is a polymer?

Who knows what answers you will get.

What about clothing? What is your clothing made of? Right, cotton. Cotton is a natural polymer. What else. Leather is another natural polymer. Good, polyester is also a polymer, but it's man-made.

There's another polymer that you "wear" all the time. Even when you're in the bathtub. Any ideas? Your skin! Your skin is a polymer too, a natural one.

Instant Snow Demo:

If you don't want to use polyox demo can replace it with instant snow demo.

Place 3 TBSPs of instant snow powder in large beaker. Ask audience is it snowing in here? Pour cup of water on powder. Let audience watch as "snow" grows instantly. Pick up some "snow" and toss it in air.

Ask audience what just happened. Dump snow into bowl, there will be a lot of "snow".

Ask a few volunteers to come up to the table and check out the "snow".

Again we have seen amazing polymers in action. It is actually the same substance as was used earlier. That powder was called sodium polyacrylate, this time in a form called "Instant Snow". Again, Sodium polyacrylate can absorb many times its own weight in water. In this form there are fewer crosslinks so it expands and form individual "snow flakes" instead of gel. The difference is the structure that the molecules are arranged in. A difference of a few cross links here and there or not is the difference between "snow" and gel being formed. In fact this is quite common in the natural world the same stuff can behave quite differently just do to the molecular structure. We are being materials scientists when we inspect these differences. Can you think of other examples of this. One example for polymers is the difference between a baked potato and a wooden baseball bat. They are almost identical except for their molecular structure which is responsible for the difference. Would you want to eat a baseball bat? What would happen if you tried to hit a fastball pitch with a potato?

Note: Poly ox demo can be difficult to get to work. You should practice before you try it at the show or leave it out of the demonstration

Poly Ox:

The people who study different substances are called materials scientists. Sometimes they are working with a material that has already been discovered. They are investigating the properties of this material. Here we have a material, a polymer called polyethylene oxide. Let's study some of its properties.

Pour 3 to 4 grams of poly ox into a beaker.

What can you see? What can you tell me about this polymer?

Take answers from the audience. It's a powder, it's white.

Now, I am going to mix it with some alcohol and wet the powder. Then I am going to add water.

First add 25 ml of alcohol and swirl until the powder has been wet completely. Then add 350 to 400 ml of water in one pour. Stir vigorously until it gels completely.

Now, as I stir this, watch the solution. What happens? Yes, it is getting thicker. It is turning into a gel. The polyethylene oxide has a lot of oxygen atoms on the chain. When it mixes with the water, those oxygen atoms can attach to the hydrogen atoms in the water in a lot of directions. These bonds are called hydrogen bonds. So the chains can stretch to become very long in all kinds of directions. When one chain breaks, a new chain can form.

The attraction of molecules to other molecules of the same type is called cohesion. This gel is very thick because it has a very high cohesion. The molecules like to stick together.

Now, I am going to pour this gel from one beaker to another. Can you see how thick it is? Now watch this.

Start to pour the gel from one beaker to another. When it starts to pull, turn the beaker you are pouring from upright. You would think it would stop pouring, but this gel actually continues to siphon.

Look what happens when I turn the top beaker back upright. The gel continues to pour. It's like it is working against gravity. This is called a siphon, and it can be done with liquids in a tube. This is so amazing, because this gel has no tube. The molecules in the chains want to stay together so much, they have such high cohesion, that they actually siphon. The molecules are pulling their friends with them in chains. It would take more energy to break the chains than to work against gravity.

Polyethylene oxide is in many products you use like shampoo, conditioner, lotion, and even some soda and beer. It helps to make the products thicker and give them a silkier feel.

We were just acting like materials scientists studying a substance we already had. But other times, materials scientists are trying to create a new material with certain properties. Let's take an example. During World War II, the United States asked a lot of different scientists to try to find a substitute for rubber. Rubber is made from rubber trees, and those don't grow in this country. The U.S. didn't want to depend on importing them, but we still needed tires. So many scientists were working on this problem. One of them was James Wright. He was trying to create a material with properties like rubber. Wright mixed together boric acid and silicone oil. What he got out was called organosiloxane polymer. But we know it today as silly putty.

Now, do you think we could use this stuff to make tires? No. It didn't work as rubber, but it is a very fun toy. Silly putty is called the real solid liquid. But I have a question for you. Is silly putty a solid, or a liquid?

Solicit some answers from the audience

This is a very tricky question. A solid holds its shape, like the table or your chairs. A liquid spreads out to fill a container, like water does. So the question is, does this silly putty spread? Remember the ball of silly putty I showed you at the start? You said it didn't have many flat spots. What about now?

Pick up the silly putty and show them the flat bottom.

It is spreading! This is a liquid. But don't feel bad if you thought it was a solid, because it is a very unusual liquid. Silly putty sometimes acts like a solid. It is called a dilatant compound. Let me show you what I mean.

Hand out small pieces of silly putty to three or four volunteers, and ask them to roll it into a ball. Have them step up and join you.

Now, volunteers, I would like you to bounce your silly putty on the floor and catch it again.

Do this yourself.

Is it still round? That's strange. If I threw a liquid on the floor, would you expect it to bounce back up in the same shape? No, you'd expect it to splatter everywhere. This shows the silly putty acting like a solid. It keeps its shape. But now, volunteers, place one finger on your ball of silly putty and slowly press down.

Do this yourself. Bring it around to show the audience.

We make a big dent in the silly putty. It is acting like a liquid and changing its shape. It turns out that when silly putty comes in contact with a hard, fast force, it acts like a solid. But when it comes in contact with a slow steady force, it acts like

a liquid. Let's see this another way. Volunteers, take your silly putty and pull it into two pieces very slowly.

Do this yourself. Show everyone the long string that is created.

When we pull it slowly, the silly putty acts like a liquid. It tries to stay in one continuous piece. Now, ball it up again. Let's pull it apart really quickly this time.

Do so. It should break into two pieces.

When I pull it quickly, the silly putty breaks into two pieces. It is acting like a solid. Give a round of applause to my volunteers.

Collect the silly putty.

I have here a five pound ball of silly putty, a fun toy. I have here a hammer. This is not a toy. What do you think is going to happen if I smash the ball of silly putty with this hammer?

Let the audience answer.

Think about hitting something with a hammer. Is it a hard, fast force, or a slow, steady force? Hard and fast! So silly putty should act like a... solid. Let's see.

Be very dramatic. Count to three. Act like this is huge. And then smash that silly putty with the hammer. It will bounce off.

It bounced! I'll bring around the silly putty and you can see a small dent, but hardly anything at all. The silly putty acted like a solid and it bounced the hammer off.

Use crusher to crush foam, wood

I want to thank everyone for coming to The Polymer demonstration. If you have any questions, come on up afterwards. My name is Professor _____, and I would be happy to answer them. Enjoy the rest of your day at the Liberty Science Center!