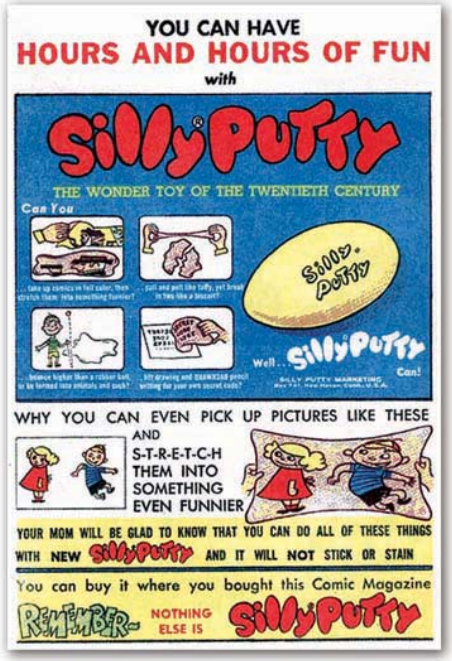
CHEMISTRY CONNECTION

Silly Putty®: Solid or Liquid?



Silly Putty—it's been a popular party favor for more than fifty years. Your parents probably played with it when they were kids. Some people call it America's longest lasting fad.

It's easy to understand why people like Silly Putty. Roll it into a ball, and you can bounce it around the room. Pull on it slowly and it will stretch out like a long lazy snake. Give it a quick yank and it will break with a satisfying *snap*.

Have you ever tried to smash a ball of Silly Putty with a hammer? It keeps its shape every time. However, if you gently press on it with your thumb, you can flatten it easily. If you leave a ball of Silly Putty on your dresser overnight, in the morning you'll see that it flattened out by itself while you were sleeping.

What's going on here?

Silly Putty isn't easy to categorize. It holds it shape when hammered, yet flows into a puddle when left alone overnight. No wonder the people who make Silly Putty call it "a real solid liquid."

Rheologists (scientists who study how matter flows and/or deforms) have another term for Silly Putty: it's a *viscoelastic* liquid.

Viscoelastic is a compound word (like *snowman*). The *visco-* part comes from the word *viscous*, which means "resistant to flow." Thick, gooey, slow-flowing liquids like hot fudge sauce are *viscous*. Silly Putty is like that.

You're probably already familiar with the second half of the word. *Elastic*, in physics terms, describes a material that returns to its original shape when deformed.

So, rheologists describe Silly Putty as a slow-flowing, elastic liquid.

How did it get that way?

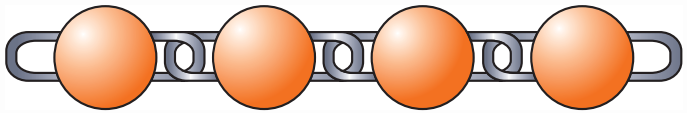
It's not too surprising that Silly Putty bounces, because it was accidentally invented by a chemist looking for a substitute for rubber. In 1943, James Wright, a researcher for General Electric, dropped some boric acid into silicone oil, creating a gooey compound.

This compound, first called "nutty putty," was sent to engineers around the world—but no practical uses were found. In 1949, a man named Peter Hodgson decided to sell it as a toy. He borrowed $147 to buy a batch from General Electric, divided the batch into one-ounce lumps, and placed each lump into a plastic egg. He renamed the compound "Silly Putty" after the main ingredient, silicone.

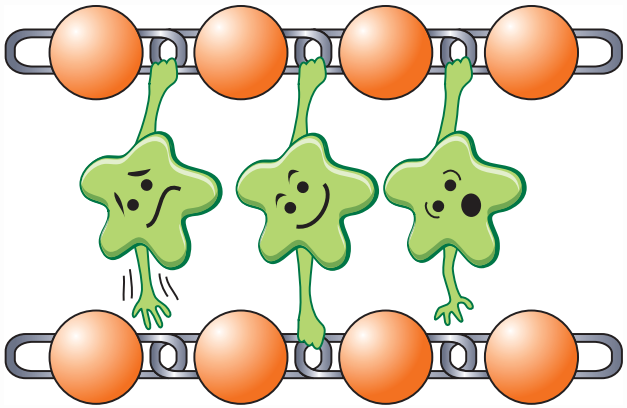
A *New Yorker* magazine reporter wrote an article about Silly Putty in 1950, and afterward Hodgson received 250,000 orders in three days. Silly Putty was a hit!

Inside Silly Putty

The silicone oil used to make Silly Putty is known to chemists as polydimethylsiloxane, or PDMS. PDMS is a polymer, which means each molecule is made up of long chain of identical smaller molecules.



When boric acid is added to the long chains of PDMS, boron crosslinks begin to form. This means that the boron hooks chains of PDMS molecules together like this:

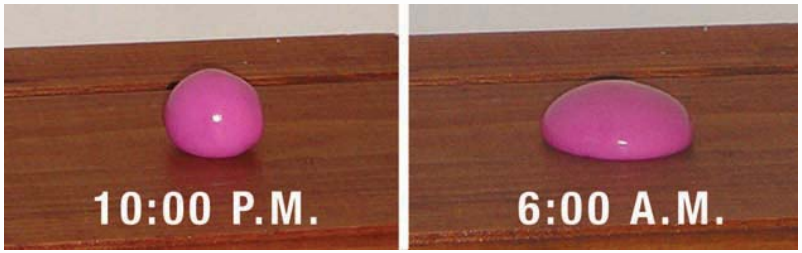


These boron crosslinks are not very strong. Remember that molecules in solids and liquids are always in motion. This motion breaks boron crosslinks, but over time new crosslinks form. This action is called *dynamic* (changing) *crosslinking*.

Because of this dynamic crosslinking, Silly Putty reacts one way to quick forces and another way to long-acting forces.

When you strike Silly Putty with a hammer, the Silly Putty reacts like an elastic solid: it bounces back. That's because most of the boron crosslinks remain in place during the split second of the hammer's strike.

When you leave a ball of Silly Putty untouched overnight, the boron crosslinks that help Silly Putty hold its shape have about eight hours to break down. Over that time, molecular motion breaks many of the original crosslinks. Gravitational force constantly pulls the PDMS molecules downward, and in the morning you're left with a Silly Putty puddle.



Questions:

1. Silly Putty does have some practical uses, despite the fact that engineers in the 1940's couldn't think of any. Find out about these using the Internet, or come up with one on your own.
2. Use the Internet to find out about a man named Earl Warrick. What was his role in the invention of Silly Putty?
3. The crew of Apollo 8 took some Silly Putty to the moon. Use the Internet to find out how the astronauts used it.

*Permission granted by Binney and Smith to publish trademark named Silly Putty.

CHAPTER ACTIVITY Make Your Own Viscoelastic Liquid

The exact recipe for Silly Putty is kept secret, but you can make your own viscoelastic liquid with ingredients you may have around the house. The homemade compound uses different molecules to form the polymer chains, but the boron crosslinks work the same way.

What you will need

White glue and water solution made in a 1:1 ratio

Borax and water solution: mix 5 mL of Borax in 60 mL of water (Borax powder is found in supermarket laundry detergent aisles)

8-ounce paper cup

Stirring stick (A tongue depressor works well)

What you will do

1. Pour 60 mL of the white glue solution into the cup.
2. Add 30 mL of the borax solution.
3. Stir the mixture for 2-3 minutes.
4. Remove the mixture from the cup and knead it with your hands. It will be sticky at first. Keep kneading until it is easy to pull the Putty away from your hands in a single lump.

Applying your knowledge

a. Develop a class procedure for measuring the Putty's bounciness and stretchiness. Compare your results with your classmates'. Was every batch of Putty the same? If not, can you suggest reasons for the differences?

b. There are lots of experiments you could do with your home-made Putty. Here are a few examples:
   1. How does temperature affect bounciness?
   2. Does stretchiness change over time?
   Choose one of these questions or make up your own question to answer about your Putty.

c. State your hypothesis.

d. Develop a procedure for testing your hypothesis. Remember, only one variable can be changed!

e. Create a data table to record your results. Here's a sample:

Temperature	Bounce height when dropped 50 cm
-10°C	
5°C	
20°C	
35°C	
50°C	

f. Carry out your experiment and record your results. What conclusion(s) can you draw?

g. Share your results with your classmates.