New Materials
A Real World Science Lesson Plan

BACKGROUND:
With the onset of WWII the US needed to make stuff fast. This itself caused shortages, but in addition access to many resources was restricted due to conflict.

This made itself most obvious in the shortage of plastics and fibers. For the first time it became really necessary to make polymers synthetically instead of just modifying natural products.

Designing polymers for specific purposes became a big industry. In reality, it had just begun by the end of WWII. Once the process began however, these synthetic polymers dominated industrial manufacturing, and still does.

OBJECTIVES:
- Students will be able define polymers, monomers, and explain the difference between synthetic and natural products.
- Students will be able to test and identify the physical properties of some unusual polymers.
- Students will be able to identify from primary sources how products were designed and marketed.

GRADE LEVEL:
5-8 with enrichment activities for advanced students

STANDARDS:
3rd-5th grades:
- Measurements of a variety of observable properties can be used to identify particular materials.. **NGSS PS1.A**
- Chemical reactions that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same. **NGSS PS1.B**

6th-8th grades:
- The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter. **NGSS PS1.A**

TIME REQUIREMENT:
Soft Circuits will probably take an hour.

Ferromagnetic Slime will probably take an hour if you have students make it, much less if they just make observations on it.

Antique Ads will take about an hour.

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MATERIALS:

For **New Materials** you will need:

- metal or glass bowl
- a Styrofoam cup
- nail polish remover

For **Soft Circuits** you will need to make the two kinds of play dough in advance. You will also need for each group:

- 1 9V battery
- 4 LED bulbs

For **Ferromagnetic slime** you will need the slime and some strong magnets. If you use neodymium, caution students that they are very strong and may pinch their fingers. Students should use eye protection when making and using the slime.

PRIOR KNOWLEDGE:

You may teach electrical circuits using the play dough. Students might find it easier than using regular wires.

INFORMATION FOR TEACHERS:

Iron oxide is inexpensive and easily acquired online or at art suppliers. Borax and liquid starch are found in the laundry aisles of large grocery stores, usually near the bleach. Cream of tartar is an archaic leavening agent, but can be found in most large groceries. Food coloring can be used to differentiate these mixtures.

OUTLINE OF ACTIVITIES:

These activities do not need to be done together.

1. In **New Materials**, read about synthetic polymers and watch a demonstration of Styrofoam dissolving.
2. In **Soft Circuits** students investigate the properties of two kinds of play dough. They can design and test different circuits.
3. In **Ferromagnetic Slime** students make and then investigate the properties of a polymer.
4. In **Antique Ads** students learn about the ways that new materials were advertised and used during WWII.

ASSESSMENT:

Student responses on handouts will provide some data on their understanding of physical properties of materials, and how engineers can create substances with the properties they want.

EXTENSION/ENRICHMENT:

There are a number of very cool things you can do to learn about electrical circuits with this special play dough. Use the Squishy Circuits site to find out more:
http://courseweb.stthomas.edu/apthomas/SquishyCircuits/buildingCircuits.htm

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Play Dough Recipes:

Non-conductive Play Dough

(Recipe is enough for 1 class—will stay good sealed in plastic for up to a month)

Ingredients:
2 cups distilled water
6 cups white flour
2 cups sugar
3/4 cup vegetable oil
Food coloring

Instructions:
Combine all 3 cups of flour and all other ingredients in a pot. Stir until it forms a ball. Using remaining flour a bit at a time, knead the dough until it reaches a nice consistency.

This dough tends to be wetter, and may need more flour over time.

Conductive Play Dough

(Recipe is enough for 1 class—will stay good sealed in plastic for up to a month)

Ingredients:
4 cups water
6 cups white flour
1 cup table salt
¾ cup cream of tartar
4 Tbsp vegetable oil
Food coloring

Instructions:
Combine 5 cups of flour and all other ingredients in a pot. Place on stove over medium heat and stir continuously. Mixture will begin to boil, and start thickening. Keep on heat, still stirring, until it forms a single ball. Remove from heat.

Place ball of dough on lightly floured surface and allow to cool. Once cool, knead remaining flour into dough until it reaches nice consistency.

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STUDENT HANDOUT

New Materials

Look around the room you are in. What are all the things in the room made of? What are your clothes, your backpack, your shoes made of? Chances are good that the answer is polymers, and that they are synthetic polymers.

Polymers are big molecules made of repeating smaller parts. Those smaller parts are called monomers. For example, sugars make chains, and long chains of sugars are cellulose (paper) or starch (potatoes or bread). Synthetic means people made it. Bread and paper are natural polymers, Styrofoam and polyester are synthetic ones.

When WWII started, people used mostly natural materials. Nearly everything was made of metal, wood or glass. Clothes were made of cotton, wool, linen, or silk. Tires and shoe soles of rubber from trees.

Scientists had known how to make their own polymers for decades, but natural sources were so inexpensive and plentiful that there was no need to use them. But that changed quickly.

The US needed so much rubber for Jeep and airplane tires, for tank treads and soldier's boots and wiring. There was no way to get all that rubber from plants, especially since the plants were grown on islands now controlled by the Japanese. Silk was grown in Asia too, and it was used for parachutes and pantyhose. Women turned in their pantyhose to make more parachutes, but it wasn't enough.

Scientists needed to make more synthetic polymers, and make them do have properties that they needed.

Fairchild advertises its use of Duramold, a new material to shape and create airplanes. The Education Collection of The National WWII Museum.

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STUDENT HANDOUT

New Materials

Watch the demonstration with the Styrofoam cup. Draw a diagram of what happens, and explain why.

Fill in the data table below. What are the things in the classroom made of? Are they natural or synthetic?

Object	Made of…	Synthetic or Natural?

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STUDENT HANDOUT

Soft Circuits

You have two kinds of dough, a battery and some lights. How can you find out which dough conducts electricity and which does not? Describe your plan below:

What were your results?

Draw a picture of the circuit you made to test the dough:

What can you make with the dough to take advantage of its unusual properties?

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STUDENT HANDOUT

Ferromagnetic Slime!

Each recipe is for one group. It may be stored sealed in plastic for a few days
There are two forms from which you might choose:

Starch recipe:

Ingredients:
¼ cup liquid starch
¼ cup white glue
2 Tbsp iron oxide powder
Optional: a few drops of food coloring

Instructions
Mix iron oxide powder into starch in a small bowl. Add in the glue and stir. Continue to stir, using hands if necessary.

Borax recipe:

Ingredients:
½ cup white glue
1½ cup water
1 tsp borax
2 Tbsp iron oxide powder
Optional: a few drops of food coloring

Instructions:
In a small bowl, mix borax into 1 cup of water until it dissolves. Add the iron oxide powder and stir well.
In a separate bowl mix the glue and the remaining ½ cup of water.
Combine the contents of the two bowls and mix until polymer forms.

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STUDENT HANDOUT

Antique Ads

New Materials were a big deal during WWII. Manufacturers advertised their products in popular magazines even though people couldn't buy them. They believed that by communicating about their efforts to support our troops in the war, people would be supportive in general of their company, and buy other things that they made. As the end of the war came, they connected in people's minds the developments they had made in wartime to new and better products.

Pick one of the two advertisements to write about.

What does it advertise? Is it a product people could buy?

Summarize what the advertisement says:

How is it different than advertisements you might see today?

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Antique Ads

PLASTICS THAT PUT

"FIGHTING MUSCLES"

IN WOOD!

BAKELITE PLASTICS MATERIALS PROPERTIES

BAKELITE PLASTICS FABRICATION METHODS

BAKELITE PLASTICS DESIGN DATA

BAKELITE resins fortify wood to win the battle against heat, cold, sea water, and mold growth!

Trees, too, are being called by "selective service"—harvested at maturity from our nation's vast replaceable resources. And—thanks to plastics research—wood can now gain strength, and resistance to the elements, never before attainable!

With the advent of resin bonding and impregnating, wood need no longer be limited in its use as "hardwood" or "softwood"—need no longer be looked upon as strong only with the grain. Through plastics research, hard woods may now be combined with softwoods, rare veneers bonded to less expensive core stocks, multiple plies crisscrossed for two-way strength. Thus, wood products gain the uniformity they have always lacked.

BAKELITE urea and phenolic resin glues make possible a superior kind of plywood. It's strong. It resists impact. It *keeps* its strength in spite of temperature changes and moisture—even sea water! Mold, which would feed and grow on natural glues, does not affect it.

Too, BAKELITE saturating resins make possible stabilized and densified woods that can form panel sections with a strength-weight ratio higher than that of most metals...*molded* woods that take varied shapes and forms.

Combined with synthetic resins, wood can now serve better than ever before...in aircraft wings and fuselages, truck and trailer bodies, prefabricated houses, ship bulkheads and superstructures. If you can use these fortified woods in essential production, the full co-operation of Bakelite Plastics Headquarters is at your service.

BAKELITE CORPORATION, 30 EAST 42ND STREET, NEW YORK, N. Y.

Unit of Union Carbide and Carbon Corporation

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BAKELITE

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PLASTICS HEADQUARTERS

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

TIME, August 10, 1942 7

Bakelite advertisement. The Education Collection of The National WWII Museum.

60 second finish!

IN THE STRATOSPHERE TODAY

ON THE SALES FLOOR TOMORROW

COATINGS that air-dry in one minute or less, yet provide maximum durability and resistance to moisture, are helping to speed the production of our fighters and bombers — giving extra protection to light metal aircraft components, and permitting quick "touch-up" of aircraft repairs in the field.

These same BAKELITE Dispersion Resins will again be available to all industry... for better, faster, more economical finishes for automobiles and trucks, for office equipment and display fixtures, for farm machines and household equipment.

There are many other equally important developments that you can know about *now* by keeping in touch with Bakelite Plastics Headquarters, both for the help Bakelite Development Laboratories and Engineering Staff can give you on today's essential production problems, and for the knowledge of plastics that you can draw upon for problems to come. Write for "A Simplified Guide to Bakelite Plastics."

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PLASTICS HEADQUARTERS

BAKELITE CORPORATION, 30 E. 42nd Street, New York

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