WONDERS OF *POLYMER SCIENCE*

Patch Requirements

(Cadettes, Seniors, Ambassadors)

SPE FOUNDATION

PLASTICS ARE *EVERYWHERE*

INSPIRING PLASTICS PROFESSIONALS

OUTCOME:

Participants will understand that plastics are everywhere—in most facets of life, that plastics are moldable, and the difference between natural and synthetic plastic.

SUPPLIES: Paper, pencil

ACTIVITY:

- Watch *Plastics Are Everywhere* video.
- Find 10 different plastic things in your home, school, or troop meeting location that you use every day.
- Discuss with your troop whether these products could be reused in a different way or recycled at the end of their life.

FOR THE TROOP LEADER:

Natural polymers are bio-degradable, meaning they naturally decompose over time. Most synthetic polymers do not decompose, so recycling these polymers is important. Recycling uses mechanical processes to separate plastic types, grind the plastic, and eventually remelt and remold it into a new shape. For hard to recycle plastics, modern technology can also use chemical processes to break the polymer bonds, creating high value monomers which can then be reused. Although some types of plastic products present challenges to the environment, many plastic products are essential to modern society in food packaging, medical applications, and consumer products.

ROY G BIV

OUTCOME:

Participants will understand basic color theory with primary and secondary colors, and the role of color in the manufacturing of plastic.

SUPPLIES: Color paddles*, color wheel*, paint, paint brushes, construction paper, scissors, glue

ACTIVITY:

- Watch the ROY G BIV video
- Color mixing: Red + yellow = orange; blue + red = purple; yellow + blue = green. Use a color wheel to help you with your choices.
- Combine colors with color paddles*.
- Make a color wheel with paint or construction paper. If using construction paper cut triangles to fit this color wheel template and create your own color wheel.
- Make color equations with paint or construction paper.

* These items are in the *Color Your World with Polymer Science* kit that can be obtained through your council.

WHERE DO PLASTICS COME FROM?

INSPIRING PLASTICS PROFESSIONALS

OUTCOME:

Participants will understand the raw materials from which plastics are made and understand that polymers are the building blocks of plastics.

SUPPLIES: Colored paper clips

ACTIVITY:

- Watch *Where Do Plastics Come From?* Video. (Watch to 5:06 minutes)
- Make a polymer model with paper clips. Keep this for the next activity.
- Research different feedstocks used to make polymers/plastics. What materials do we use to make plastics?
- Categorize the feedstocks into RENEWABLE vs. NON-RENEWABLE
- What are the advantages and disadvantages of using renewable feedstocks?

PROCEDURE:

Each paper clip represents a monomer. Each color represents the same monomer. Another color is a different monomer. Make two chains of clips to form two straight polymers of the same color. Move the polymer chains around to see how easy they move past each other. Now, create parallel lines with your chains. Crosslink the polymer by taking several paper clips and connecting the two polymer chains (think of an "H" formation). Is it easier to move the separate polymer chains or the crosslinked chains?

WHERE DO PLASTICS COME FROM?

INSPIRING PLASTICS PROFESSIONALS

FOR THE TROOP LEADER:

The smaller molecules that come together to form polymers are called monomers. Think of monomers like paper clips that link together to form a polymer chain. Polymers are many monomers linked together in chains of 50k to 500k monomers long. Some raw materials (feedstocks) used to make plastics include:

Non-renewable: crude oil, natural gas
Renewable: corn, sugar cane, or castor beans.

To make plastics, chemists and chemical engineers must do the following on an industrial scale: (From *https://science.howstuffworks.com/plastic5.htm*)

First, they must start with various raw materials used to make the monomers. Ethylene and propylene monomers, for example, can come from crude oil which contains hydrocarbons. The hydrocarbon-monomer building blocks are extracted from the "cracking process" used in refining oil and natural gas.

Next, the monomers undergo polymerization reactions in large manufacturing plants. The reactions combine monomers into long chains to produce polymer resins. Further processing, called "compounding" can include mixing in additives like reinforcements, fillers, colorants, and flame-retardant chemicals. The finished polymer resins are usually in the form of pellets or beads.

Finally, the polymer resins are used to manufacture plastic products. They are heated, molded, and allowed to cool. There are several processes involved in this stage, depending upon the type of product.

- **Extrusion:** Pellets are heated and mechanically mixed in a long chamber, forced through a specifically shaped opening (a die), and cooled with air or water. Extrusion is the backbone of several manufacturing processes. This method is used to make plastic films, sheets, and tubes. This process is like a Play-Doh machine, or the way pasta shapes are made.

WHERE DO PLASTICS *COME FROM?*

- **Injection molding:** The resin pellets are heated and mechanically mixed in a chamber and then forced under high pressure into a cooled mold. This process is used to make many products that require complex 3D shapes like cell phone cases, toys, automotive parts, etc.
- **Blow molding:** This technique is used together with extrusion and/or injection molding.
    - In extrusion blow molding, the resin pellets are heated, a molten plastic tube is extruded into a mold, and compressed air gets blown into the mold. The air expands the hot plastic against the walls of the mold forming a bottle or hollow item. This process is used to make milk jugs, shampoo bottles, and laundry detergent bottles.
    - In Injection stretch blow molding, a bottle preform is made with an injection molding machine. The preform is then shipped to a bottling plant where it is reheated in a mold and air is blown into it to form the bottle. This process is used to make water and carbonated beverage bottles.
- **Rotational molding:** The resin powders are heated and cooled in a mold that can be rotated around all three axes. The rotation evenly distributes the plastic along the walls of the mold. This technique is used to make large, hollow, plastic toys, furniture, sporting equipment, septic tanks, garbage cans and kayaks.

POLYMER *STRUCTURES*

OUTCOME:

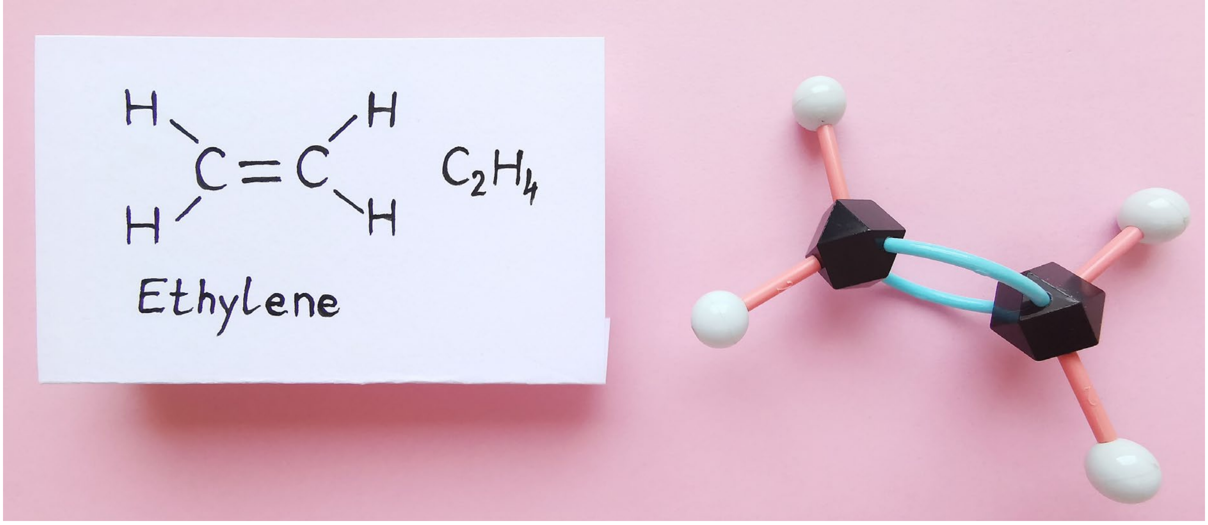
Participants will understand the difference between natural and synthetic plastic and will understand the structure of polymers.

SUPPLIES:

Balloons*, skewers (thin), hand lotion, cooked and uncooked spaghetti (or use paper clip polymer model).

ACTIVITY:

- Watch *Polymeric Structures* video.
- Manipulate polymers of a balloon. See procedure below.
- Research what a particular polymer looks like and recreate it. Using discarded plastic items (either consumer goods or packaging), design a creative or artistic model of a polymer. Also, research what a particular polymer looks like and recreate it. For example: polyethylene is used to make laundry detergent bottles and the chemical formula is $(C_2H_4)_n$ and can be modeled like:



POLYMER *STRUCTURES*

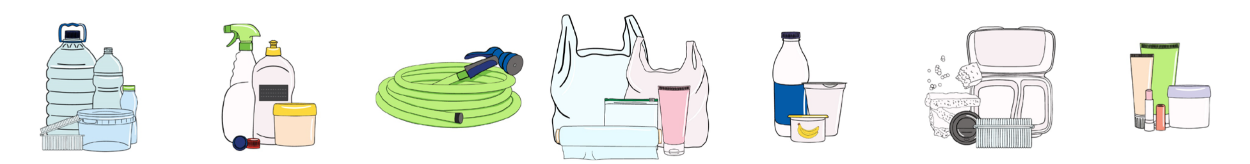
PROCEDURE:

For the balloon activity follow the directions in the video. Before inserting the skewer into the balloon, slide it into the hand lotion bottle to make the skewer slippery. When inserting the skewer into the balloon start at the knotted end (but not in the knot) and insert into the darkest area where the polymers are denser. Bring the skewer out the opposite end again where it is the darkest therefore densest area. Move slowly and twist the skewer into the balloon.

FOR THE TROOP LEADER:

RESIN IDENTIFICATION CODES (RIC) FOR PLASTIC

1	2	3	4	5	6	7
PETE or PET	**HDPE or PE-HD**	**PVC or V**	**LDPE or PE-LD**	**PP**	**PS**	**O or N/A**
Polyethylene Terephthalate	High-Density Polyethylene	Polyvinyl Chloride	Low-Density Polyethylene	Polypropylene	Polystyrene or Styrofoam	Other
soda bottles, water bottles, polyester film, containers for food, jars, fibers for clothing	detergent containers, plastic bottles, piping for water and sewer, snowboards, boats	window frames, plumbing products, electrical cable insulation, clothing, medical tubing	shopping bags, plastic bags, clear food containers, disposable packaging	plaboratory equipment, automotive parts, medical devices, food containers	CD and DVD cases, packing peanuts, single-use disposable cutlery, trays	baby feeding bottles, car parts, water cooler bottles, sippy cups



SLIME!

SPE INSPIRING PLASTICS PROFESSIONALS

OUTCOME:

Participants will understand that slime is a crosslinked polymer and the properties of a non-Newtonian fluid.

SUPPLIES: Elmer's clear glue (diluted 50:50 with water), powdered Borax for cross linking (find it at the grocery store in the laundry aisle), measuring spoons, plastic cups, water, food coloring*, small plastic "snack" bags

ACTIVITY:

- Watch the *Slime* video to:
  - 2:43 to make the traditional slime
  - 3:58 to make a slime variation
  - 5:19 for the viscosity race
- Make Slime

PROCEDURE:

- To make 4% Sodium Borate solution: Dissolve 1 Tbsp of *20 Mule Team* borax powder into 2 ⅔ cups warm water.
- To make 50% Elmer's glue solution: Combine 3 cups Elmer's glue with 3 cups water. Stir until mixed.
- Color the diluted clear or white glue with food coloring making red, blue, and yellow.
- Condiment bottles work very well to squeeze the liquids into Ziploc bags. **The ratio of glue to borax solution is 2:1.** You can eye-ball the amounts needed or mark the corner of the bag for pre-measuring. Mix the glue and food coloring first to create the desired colors, then mix (crosslink) it with borax solution, in the bag, to make slime. Using the color wheel, you can figure out how to make any color.

SLIME!

FOR THE TROOP LEADER:

When "stirring" the slime, ask participants them if it feels cool or warm. (cool). Discuss that this is an example of an endothermic reaction—one that takes 'in' heat. An endothermic reaction absorbs energy (heat) instead of giving off energy (heat). An endothermic reaction feels cool because the reaction pulls heat from your finger into the slime. An exothermic reaction would feel warm/hot to the touch.

WHAT IS A NON-NEWTONIAN FLUID?

Pressure-sensitive substances, like slime (and silly putty and quicksand) are non-Newtonian fluids. In a non-Newtonian fluid, viscosity can change when under force to either more liquid or more solid.

Often a substance changes its state because of a change of temperature—like freezing water to make a solid ice cube or boiling water to make steam which is a gas. But this simple mixture shows how changes in force, and the rate it's applied, can also change the properties of some substances.

The slime will behave differently depending on the amount and speed of force applied. Let it sit on a surface or in a cup or bag and observe how it slowly moves like a super thick fluid. Roll the slime into a ball and drop it from about 20 inches on a hard surface and observe how it behaves like a bouncy solid.

When pressure is applied quickly to a non-Newtonian fluid (like when you hit it or drop it) it increases the thickness (or viscosity). A fast tap on the top of the slime and it feels hard, but if you press your finger in slowly the mixture is fluid. Moving quickly forces the molecules together, without giving them time to move apart. Moving slowly allows time for the molecules to move out of the way.

* These items are in the *Color Your World with Polymer Science* kit that can be obtained from your council.

THERMOPLASTICS & *RECYCLING*

SPE INSPIRING PLASTICS PROFESSIONALS

OUTCOME:

Participants will understand the raw materials from which plastics are made and understand that polymers are the building blocks of plastics.

SUPPLIES: Polly Plastics™ sticks*, water, something to heat water in, tongs, scissors, colored mica powder*

ACTIVITY:

- Watch *Thermoplastics and Recycling* video
- Mold Polly Plastics™ into different shapes. Add color.

PROCEDURE:

Cut the white Polly Plastics™ sheets provided into squares about 1.5 in^2. Ask everyone to identify the physical properties of the thermoplastic stick before you put it in the boiling water. (Properties: rigid, smooth, rectangle shape, shiny, matte, etc.). Using tongs, the troop leader will place the Polly Plastics™ stick in the heated water. Swish back and forth. The plastic will turn clear when ready to mold. Remove it from the water, letting the hot water drip off, then hand it to the participant to begin molding the plastic. The plastic will be warm but not too hot to handle. Discuss the physical properties of the Polly Plastics™ after it was heated and how they changed. (Properties: soft, warm, moldable, etc.).

Put the mica powder on a plate. Reheat the plastic and have the girls quickly dip the warm plastic into the mica powder (you need very little). Mix the mica colorant into the plastic while remolding it. Observe how the physical properties are changing. Adding colorant in the form of mineral powder changes some properties of the plastic e.g., making it stiffer or harder to mold. Manufacturers add different things to plastics to change the properties of materials.

THERMOPLASTICS
& *RECYCLING*

FOR THE TROOP LEADER:

Plastics can be divided into two major categories:

- **Thermosets:** Once cooled and hardened, these plastics retain their shapes and cannot return to their original form. They are hard and durable. Thermosets can be used for auto parts, aircraft parts, and tires. Examples include polyurethanes (furniture coatings), polyesters (shower enclosures), epoxy resins (adhesives) and phenolic resins (counter tops).
- **Thermoplastics:** Less rigid than thermosets, thermoplastics can soften upon heating and return to their original form. They are easily molded and extruded into films, fibers, and packaging. Thermoplastics are 100% recyclable. In ideal situations thermoplastics can be repeatably melted and remolded into new products. This is the foundation of recycling. Examples include polyethylene (milk jugs), polypropylene (yogurt cups) and polyethylene terephthalate (water bottles).

A cooked egg is a good thermoset example. After heating an egg, you can cool it or reheat it, but it will never return to its liquid state. It remains solid, just as thermoset polymers do. But if you cool melted cheese, it regains its solid form. Reheat it and it flows again, just like thermoplastics.

*These items are in the Color Your World with Polymer Science kit that can be obtained from your council.

CAREER *EXPLORATION*

SPE Inspiring Plastics Professionals

CHOOSE ONE OPTION:

- Find 3 careers in plastics that interest you. Choose one and click to complete this career card. You can start with the websites below or do an internet search using the keywords below.
- The Texas universities listed have student Society of Plastics Engineers chapters. Explore their academic degrees to find out more about their programs which support the plastics industry.
  - Baylor University, Waco
  - Lamar University, Beaumont
  - Texas A&M, Kingsville
  - Texas State University, San Marcos
  - Texas Tech University
  - University of North Texas
  - University of Houston

KEYWORD SEARCH FOR CAREERS:

- Appliance Design, Applications Engineer, Automotive Engineer
- Business Analyst, Chemical Engineer, Chemist
- Economic Analyst, Electrical Engineer, Industrial Engineer
- Injection Molding, Material Engineer, Material Scientist, Mechanical Engineer
- Packaging Engineer, Polymer Engineer, Polymer Scientist, Process Engineer
- Plastics Engineer, Supply Chain Manager, Toy Designer, Transportation Management

Schools with programs in Polymer Science and Plastics Engineering:

- University of Southern Mississippi: USM-polymer science
- University of Akron
- Pennsylvania State University: PSU-Materials Science and Engineering
- Ferris State University
- University of Massachusetts–Lowell
- Shawnee State University: Shawnee State Plastics Engineering Tech
- University of Wisconsin-Stout
- Western Washington University

Career Websites:

- Women in Plastics on Careers, Challenges, and the Future
- Indeed - 12 Plastics Industry Jobs (With Duties and Salaries)