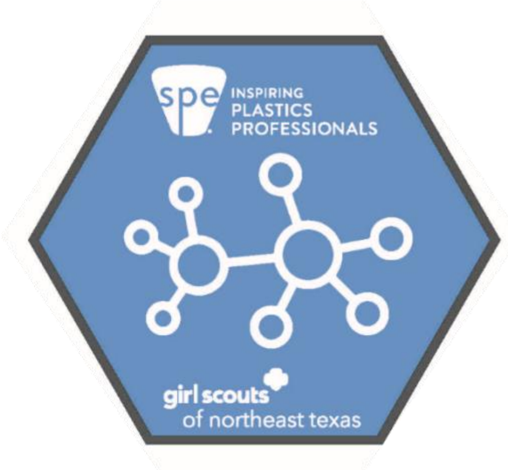
Wonders of Polymer Science Patch Requirements

(Cadettes, Seniors, Ambassadors)



Plastics are Everywhere!

Goal: Scouts 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.
- Identify Natural and Synthetic Polymers: The troop leader calls out the name of an object (see examples below) and the girls yell out if it is a synthetic or natural polymer. Or an alternative approach: troop leader yells synthetic or natural and the girls yell out a name of an object or item they see.
    - Synthetic polymer examples: eye glass frames, back packs, shoe soles, polyester clothes, pens, phone cases, water bottle, plastic cups, straws, food packaging.
    - Natural polymer examples: hair, fingernails, DNA, silk, latex.

Background Information:

Natural polymers are bio-degradable, meaning they naturally decompose over time. Most synthetic polymers do not decompose so recycling 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.

Outcome: Students understand that a plastic-free world is impossible, and that responsible use, recycling, and disposal of plastics is most important.

ROY G BIV

Goal: Scouts 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
- Combine color paddles from the kit to mix secondary colors.
- Do 1 of these activities:
    - Make a color wheel with paint or construction paper. If using construction paper cut triangles to fit the color wheel found at www.4spe.org/scoutpatch.
    - Make color equations with paint or construction paper.
      Red + Yellow = ?; Blue + Yellow = ?; Red + Blue = ?

Outcome: Students will apply color theory when they add color in upcoming polymer activities. Students will understand how color is added to plastics to make vibrant colors.

*These items are in the Wonders of Polymer Science kit found at the scout store.

Where do Plastics Come From?

Goal: Scouts 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 non-renewable feedstocks?
- What are the advantages and disadvantages of using renewable or biomass feedstocks?

Procedure: Each paper clip represents a monomer. Each color represents the same monomer. Another color is a different monomer. Make a chain of clips to form a single straight polymer of the same color. Move the polymer chain around to see how easy it is to move. Create two polymer lines parallel to each other. Crosslink the polymer by taking 1-2 paper clips and connecting the two polymer chains (think of an “H” formation). Is it easier to move the single polymer chain or the crosslinked chain?

Background Information:

The smaller molecules that come together to form polymers are called monomers—**small units that link together over and over to form a large polymer**. Think of monomers like paper clips that link together to form a polymer chain. Polymers are many monomers linked together.

Some raw materials (feedstocks) used to make plastics include crude oil, natural gas, 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 that make up the monomers. Ethylene and propylene, for example, can come from crude oil, which contains the hydrocarbons that make up the monomers. The hydrocarbon raw materials are obtained from the "cracking process" used in refining oil and natural gas. Once various hydrocarbons are obtained from cracking, they are chemically processed to make monomers used in plastics.

Next, the monomers undergo polymerization reactions in large polymerization plants. The reactions produce polymer resins, which are collected and further processed. Processing can include the addition of plasticizers, dyes, and flame-retardant chemicals. The final polymer resins are usually in the forms of pellets or beads, sometimes called nurdles.

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 part of several manufacturing processes. This method is used to make plastic films.
- **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 for many consumer goods e.g., cell phone cases.
- **Blow molding:** This technique is used in conjunction with extrusion. In one process, the resin pellets are heated, and the molten plastic is dropped into a mold, 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 plastic bottles.
- **Rotational molding:** The resin pellets are heated and cooled in a mold that can be rotated in three dimensions. The rotation evenly distributes the plastic along the walls of the mold. This technique is used to make large, hollow plastic items (toys, furniture, sporting equipment, septic tanks, garbage cans and kayaks).

Outcome: Students understand that plastics are made up of monomers joined together to form polymers.

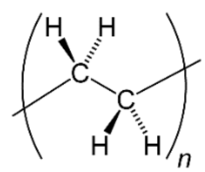
Polymer Structures

Goal: Scouts will understand the difference between natural and synthetic plastic. Scouts 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 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. Use discarded plastic items, either consumer goods or packaging and design a creative or artistic model of a polymer. Scouts can 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:



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.

Background information:

The smaller molecules that come together to form polymers are called monomers—**small units that link together to form a large polymer**. Think of monomers like paper clips that link together to form a chain, and that chain is a polymer. Polymers are made of many monomers linked together. Another model to consider: one Lego brick is a monomer and the structures you build with the Lego bricks are polymers.

Plastics and Common Uses

#1 Polyethylene Terephthalate (PETE)	Soft drink and water bottles, cleaner bottles, peanut butter containers
#2 High-Density Polyethylene (HDPE)	Milk Jugs, shampoo bottles, laundry detergent bottles, some plastic bags
#3 Polyvinyl chloride (PVC)	Cling wrap for food, window cleaner bottles, medical vinyl tubing, shower curtains, flooring, and home siding
#4 Low-Density Polyethylene (LDPE)	Most plastic wraps, bread bags, frozen food bags, single-use grocery bags
#5 Polypropylene (PP)	Yogurt containers, syrup bottles, outdoor carpet, disposable diapers, deli containers
#6 Polystyrene (PS)	Disposable plates, disposable cups, meat trays, egg cartons, carry-out containers, straws, building insulation

Find more information at:

https://www-tc.pbs.org/strangedays/pdf/StrangeDaysSmartPlasticsGuide.pdf

Outcome: Students will understand plastics are polymers and that polymers are different based on the configuration of the molecules.

*These items are in the Wonders of Polymer Science kit found at the scout store.

Slime

Goal: Scouts 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**.** Grades K-5 watch to 2:43 minutes.
- Make Slime

Procedure:

- To make 4% Sodium Borate solution: Dissolve 1/3 cup of *20 Mule Team* borax powder into 8 1/2 cups warm water.
- Color the diluted clear 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. The scouts mix the glue first to create secondary colors, then mix (crosslink) it with borax solution in the bag to make. The girls can figure out how to make any color using their color wheel.

Background information:

When the scouts are “stirring” the slime ask 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-dependent 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 can also change the properties of some substances.

The slime will behave differently depending on the amount 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 to a non-Newtonian fluid (like when you squeeze) it increases the thickness (or viscosity). A fast tap on the top of the slime and it feels hard, but if you dip your finger in slowly the mixture is fluid. Moving slowly allows time for the cross-linking particles (in this case the Borax) to move out of the way.

Outcome: Students will understand that non-Newtonian fluids change viscosity depending on the type of force applied to either more liquid or more solid.

Thermoplastics and Recycling

Goal: Scouts will understand how thermoplastics are used in manufacturing and recycling.

Supplies: Polly plastic sticks*, water, something to heat water in, tongs, scissors, colored mica powder*

Activity:
- Watch *Thermoplastics and Recycling* video
- Mold Polly Plastic into different shapes. Add color.

Safety Warning: This activity involves heating water. Do with adult supervision only.

Procedure: Cut the white Polly Plastic sheets provided into squares about 1.5 in^2. Ask the girls 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 Plastic 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 scout to begin molding the plastic. The plastic will not be too hot to handle. Discuss the physical properties of the Polly Plastic 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 coloring 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.

Background information:

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, polyesters, epoxy resins and phenolic resins.

- **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 (PE), polypropylene (PP) and polyethylene terephthalate (PET).

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.

Outcome: Students understand that thermoplastics can be reheated and remolded into new products.

*These items are in the Wonders of Polymer Science kit found at the scout store.

Career Exploration (Seniors, Ambassadors only)

Choose one option:

- Find 3 careers in plastics that interest you. Choose one and complete the Career Card found at www.4spe.org/scoutpatch. You can start with the websites below or do an internet search using the keywords below.
- Find out more about the Plastics programs at two universities listed below.

Keyword search for careers:

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

Career websites:

- https://digital.iapd.org/issue/august-september-2021/women-in-plastics-on-careers-challenges-and-the-future/
- https://www.indeed.com/career-advice/finding-a-job/plastics-industry-jobs

Schools with programs in Polymer Science and Plastics Engineering:

- University of Southern Mississippi: USM-polymer science
- University of Akron: https://www.uakron.edu/polymer/
- Pennsylvania State University: PSU-Materials Science and Engineering
- Ferris State University: Ferris State plastics programs
- University of Massachusetts–Lowell: UM-Lowell plastics-engineering
- Shawnee State University: Shawnee State Plastics Engineering Tech
- University of Wisconsin Stout: University of Wisconsin-Stout Plastics Engineering
- Spotlight on Texas universities:
  - Baylor University, Waco
  - Lamar University, Beaumont
  - Texas A&M, Kingsville and College Station
  - Texas State University, San Marcos
  - Texas Tech University
  - University of North Texas, Denton
  - University of Houston