

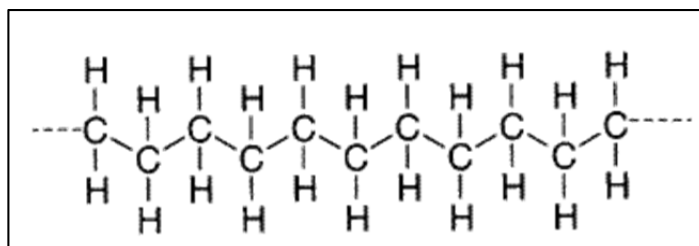
Chemical technologies present both risks and benefits to the health and well-being of humans, plants and animals.

Objective: Students will investigate a synthetic polymer (polyethylene) and how the polymer can be processed to produce products with different characteristics.

Polymers are large molecules consisting of chains of small molecules called monomers joined together in a repeating pattern. Polymers have been with us since the beginning of time. Natural polymers include such things as tar and shellac, tortoise shell and horns, as well as tree saps that produce amber and latex. These polymers were processed with heat and pressure into useful articles like hair ornaments and jewelry. Natural polymers began to be chemically modified during the 1800s to produce many materials. The most famous of these were vulcanized rubber, gun cotton, and celluloid. The first synthetic polymer produced was Bakelite in 1909 and was soon followed by the first semi-synthetic fiber, rayon, which was developed in 1911.

Even with these developments, it was not until World War II that significant changes took place in the polymer industry. Prior to World War II, natural substances were generally available; therefore, synthetics that were being developed were not a necessity. Once the world went to war, our natural sources of latex, wool, silk, and other materials were cut off, making the use of synthetics critical. During this time period, we saw the use of nylon, acrylic, neoprene, SBR, polyethylene, and many more polymers take the place of natural materials that were no longer available. Since then, the polymer industry has continued to grow and has evolved into one of the fastest growing industries in the U.S. and in the world.

Many common classes of polymers are composed of hydrocarbons. These polymers are specifically made of small units bonded into long chains. Carbon makes up the backbone of the molecule and hydrogen atoms are bonded along the backbone. To the right is a diagram of polyethylene, the simplest polymer structure.



There are polymers that contain only carbon and hydrogen (for example, polypropylene, polybutylene, polystyrene, and polymethylpentene). Even though the basic makeup of many polymers is carbon and hydrogen, other elements can also be involved. Oxygen, chlorine, fluorine, nitrogen, silicon, phosphorous, and sulfur are other elements that are found in the molecular makeup of polymers. Polyvinyl chloride (PVC) contains chlorine. Nylon contains nitrogen and oxygen. Teflon contains fluorine. Polyesters and polycarbonates contain oxygen. Vulcanized rubber and thiokol contain sulfur. There are also some polymers that, instead of having carbon backbones, have silicon or phosphorous backbones. These are considered inorganic polymers. One of the most famous silicon-based polymers is Silly Putty.

For our lab we are going to focus on the synthetic polymer polyethylene. They developed it by repeating units of the monomer ethylene ($H_2C=CH_2$). As shown above polyethylene is a very large, zigzag-shaped molecule.

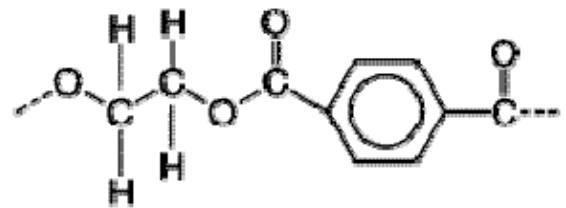
Chemists and engineers have learned to process and modify molecules of polyethylene in different ways to manufacture common household products with a variety of characteristics. Polyethylene is used to make plastic trash bags, dry cleaning bags, milk jugs and soda bottles. In industry, materials made from polyethylene are tested for what are called “stress-strain behaviors.” Stress-strain behaviors include:

- **tensile strength** - the amount of pulling force placed upon a material before it breaks
- **abrasion resistance** - toughness of material against scraping, scuffing or scarring
- **puncture resistance** - ability of a material to keep moving objects from perforating the surface

Common Plastic Resins Used in Packaging

Polyethylene Terephthalate (PET or PETE)

PET is clear, tough and has good gas and moisture barrier properties. The vast majority of this plastic ends up in soft drink bottles and blow molded containers, although sheet applications are increasing. In addition, a small volume of PET is now used outside the packaging industry for the production of injection molded components such as bicycle mud guards. Cleaned, recycled PET flakes and pellets are in great demand for spinning fiber for carpet yarns and producing fiberfill and geotextiles. Other outlets include strapping, molding compounds and both food and non-food containers.



Qualities: Clarity, strength/toughness, barrier to gas, resistance to grease/oil, stiffness, resistance to heat.
Uses: Plastic soft drink bottles, mouthwash bottles, peanut butter and salad dressing containers.
Recycled Products: Tote bags, dishwashing liquid containers, clamshells, laser toner cartridges, picnic tables, hiking boots, lumber, mailbox posts, fencing, furniture, sweatshirts.

High Density Polyethylene (HDPE)

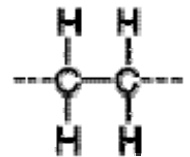
HDPE is a relatively straight chain structure, but, as its name implies, exhibits a higher density. It is naturally milky white in appearance and finds wide application in blow molded bottles for milk, water and fruit juices. Copolymer HDPE, pigmented with a variety of colorants, is used for packaging toiletries, detergents and similar products.



Qualities: Stiffness, strength/toughness, low cost, ease of forming, resistance to chemicals, permeability to gas, ease of processing.
Uses: Milk, water and juice containers, grocery bags, toys, liquid detergent bottles.
Recycled Products: Recycling bins, benches, bird feeders, retractable pens, clipboards, fly swatters, dog houses, vitamin bottles, floor tile, liquid laundry detergent containers.

Low Density Polyethylene (LDPE)

A plastic used predominantly in film applications due to its toughness, flexibility and relative transparency. Because of its lower melting point at a given density, it is used in applications where heat sealing is easily accomplished. LDPE is the preferred resin on older unconverted film extrusion equipment due to its ease of extrusion. Typically, LDPE is used to manufacture flexible films such as those used for plastic retail bags and garment dry cleaning and grocery bags. LDPE is also used to manufacture some flexible lids, and it is widely used in wire and cable applications for its good insulatory electrical properties and processing characteristics.



Qualities: Ease of processing, barrier to moisture, strength/toughness, flexibility, ease of sealing, low cost.
Uses: Bread bags, frozen food bags, grocery bags.
Recycled Products: Shipping envelopes, garbage can liners, floor tile, furniture, film, compost bins, paneling, trash cans, landscape timber, mud flaps.

Name: _____

Period: _____

1. What is a polymer?
2. What is a monomer?
3. Name two natural polymers
4. What was the first synthetic polymer?
5. Why was WWII responsible for the increased development of synthetic polymers?
6. What is polyethylene?
7. Name the two elements that make up polyethylene.
8. What are three common uses of polyethylene?
9. What is PETE used for? What are its qualities?
10. What is HDPE used for? What are its qualities?
11. What is LDPE used for? What are its qualities?

Your Task

Your team will design an experiment that investigates a stress-strain behavior among various plastic products made of the synthetic polymer polyethylene.

You will have access to the following materials and equipment. It may not be necessary to use all of the equipment that has been provided.

Materials:

plastic dry cleaning bags	sandpaper (coarse and fine)	markers
clear kitchen wrap	empty coffee cans	safety goggles
plastic sandwich bags	rubber bands	ruler
ball bearings (different masses)	ring stands or clamps	scissors

1. State the problem you are going to investigate.
2. Write a hypothesis using an "If (type of plastic) is ... then ... because ..." statement that describes what you expect to find and why.
3. Identify the independent variable: _____
4. Identify the dependent variable: _____
5. Design an experiment to test the problem. Your experimental design should match the statement of the problem and should be clearly described so that someone else could easily replicate your experiment. Include a control if appropriate and state which variables need to be held constant.
6. Review your design with your teacher before you begin your experiment.
7. Create a data table where you will record data during the experiment
8. Conduct your experiment. While conducting your experiment, take notes on your observations and record your data in your table.

Name: _____

Period: _____

Testing Synthetic Polymers

Category	Objective	Points Possible	Student Score	Teacher Score
Statement of Problem and Hypothesis 8 points	The problem is stated clearly and completely	2		
	The hypothesis is stated clearly and completely	2		
	Clear identification of independent variable	2		
	Clear identification of dependent variable	2		
Experimental Design 10 points	The experimental design matches the stated problem.	2		
	Variables are held constant.	2		
	A control is included when appropriate.	2		
	The procedures are described in clear and complete language.	4		
Data Presentation 16 points	Class data table is well organized and presented in an appropriate manner.	4		
	Class data is presented as a bar graph	4		
	Graph has a title, labeled axis, key	4		
	Graph has an appropriate scale (graph should fill page)	4		
Conclusions 12 points	Conclusions are fully supported by data and address the hypothesis.	4		
	Your conclusion uses data from both your group and the class	4		
	Reliability of data and validity of conclusions are thoroughly discussed.	4		
Total		47		