INTRODUCTION TO POLYMERS

I. Question

What is a polymer?

II. Background Information

Polymers have been around 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 rubber, gun cotton, and celluloid. The first synthetic polymer produced was Bakelite in 1909 and was soon followed by the first synthetic fiber, rayon.

It was not until World War II that significant changes took place in the polymer industry. Natural polymers were no longer readily available, and it became necessary to synthesize polymers. Since then, the polymer industry has continued to grow.

What is a polymer? The simplest definition of a polymer is something made of many units. Think of a polymer as a chain. Each link of the chain is the "-mer" or basic unit that is made of carbon, hydrogen, oxygen and/or silicon. To make the chain, many links or "-mers" are hooked or polymerized together. If only one type of "-mer" is polymerized, it is called a "monomer" instead of a "polymer."

Many classes of polymers are made of just carbon and hydrogen. These polymers are specifically made of small units bonded into long chains. Carbon makes up the backbone and hydrogen atoms are bonded along the backbone. Monomers are chemically joined together in one of two ways: condensation polymerization or addition polymerization.

Just as the name implies, addition polymerization occurs when the "-mers" add together in a long chain. There are three basic steps in addition polymerization: initiation, propagation and termination. Initiation is the first step of a chain reaction. For example, to get ethylene to form the polymer "polyethylene", the double bond has to break. Once broken, the unattached carbons will find another carbon it can bond with. This starts a chain reaction known as the propagation step. The double bonds of the remaining ethylene monomers are broken and added onto the chain. When there are no remaining monomers, the reaction stops, or terminates. We can also "quench" the reaction by cooling it down enough to terminate, or stop, before all the monomers are consumed. In a condensation reaction, a small molecule (usually water) is eliminated as the monomers join together.

III. Materials

Overhead projector
"Polymer Structure" transparency (see end of section)
Ethylene monomers

IV. Procedure

1) Break students into groups of 4 to 6. Have each group record about how long they think polymers have been around, what their ideas of polymers are and list 10 different polymer products they have used within the past week. (Circulate around the room to see what ideas they have. This is a good time for you to get a feel for how much they already know so you will be able to adapt your lesson accordingly. If their list shows that they understand how polymers are used, get them to classify the items they listed by their properties. Let them decide what those properties should be.)
2) Give a brief history of polymers. (Ask how many groups knew natural polymers have been around as long as there have been living things.)
3) Give each student an ethylene monomer. Explain the basic chemistry of ethylene. Start by drawing a single ethylene molecule on either the chalkboard or overhead. Explain why there is a double bond between the carbons. (Because students at this age are very social, use the analogy of carbon needing to have four friends around at all times. When it can't have four friends, it makes up for it by "double bonding" to a neighboring carbon.) Have students bend their monomer into a double-bond.
4) Explain the basic ideas of polymerization by simply explaining the concept of adding on or linking monomers to form chains. (Here's where it starts to get fun! Tell a few ways your double bond could get broken, then break your bond. Ask the students if they have any suggestions how you can fix your problem. They'll eventually come up with the idea of you breaking the double bond of a close by monomer. Allow the chain reaction to progress throughout that group then continue throughout the class. When all the monomers have been added to the chain, end the reaction by letting the last two available carbons bond with a hydrogen.) Once the students have completed the polymerization simulation, introduce the terms initiation, propagation and termination.
5) Make a compilation of the groups' polymer lists. Have the class find a way to group the items in the combined list. (Ask them why they chose their categories. Extend their thinking by having them think of a different way to sort.)
6) Display the overhead of the "Polymer Structures" and talk about the different structures and simply point out different chemicals in the various structures. Explain why chemical composition is the best way to group recyclables.
7) (Close the lesson) Discuss the importance of recycling. List products that are made from recycled plastics.
   - Plastics deteriorate but never decompose completely (nor do glass or aluminum)
   - In 1994, Americans produced 209.1 million tons of trash
     Plastics = 9.5%
     Paper = 38.9%
     Glass & Metals = 13.9

- New applications for recycled plastics are being developed every day

V. Chemistry

See overhead

VI. Discussion and Evaluation

Discussion of the various properties of all of the plastics should be included as the lesson progresses. *(Some are flexible, some are transparent, some have an odor, some are smooth, etc.).*

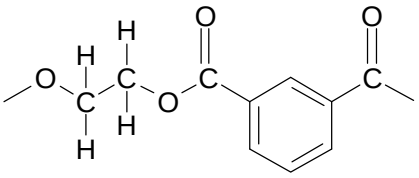
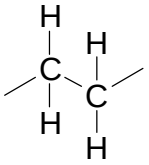
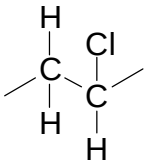
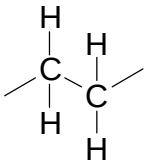
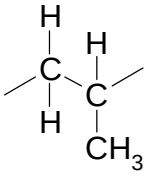
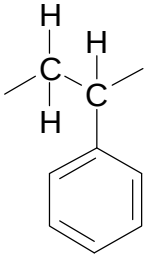
VII. Continuing the Concept

Students will learn how to identify and separate plastics using density in the Plastics Identification experiment.

VIII. References

Hands On Plastics: A Scientific Investigation Kit
www.handsonplastics.com

Recycling Codes and Chemistry

Recycling Code	Name of Polymer	Sample Uses	Structure
1	polyethylene terephthalate (PET or PETE)	soft drink bottles• carpets• fiberfill• rope• scouring pads• fabrics• Mylar tape (cassette)	
2	high density polyethylene (HDPE)	milk jug• detergent bottles• bags• plastic lumber• garden furniture• flower pots• signs• trash cans	
3	Polyvinyl chloride or vinyl (PVC or V)	cooking oil bottles• drainage and sewer pipes• tile• bird feeders• credit cards• institutional furniture	
4	low density polyethylene (LDPE)	bags• wrapping films• container lids• Elmer's® glue bottles	
5	polypropylene (PP)	yogurt containers• automobile batteries• bottles• carpets• rope• wrapping films• lab equipment	
6	polystyrene (PS)	disposable cups and utensils• toys• lighting and signs• foam containers and insulation	
7	all other polymers	catsup, snack and other food containers• hand cream, toothpaste and cosmetic containers