The stress of a Recycled Bag Teacher Notes

This lesson is designed to accompany an introduction to polymers for a secondary science class. However, it could be used as a stand- alone activity or it may be used as the introductory lesson to polymers.

One goal of this lesson is to have students discover properties of a polymer that are caused from its molecular structure. The basic idea that polymers are long chains of molecules is evidenced by tensile stress and strain exhibited when these chains are aligned and pulled in a direction to break the chains all at once, or in a direction to separate and gradually break the chains in smaller numbers. Polyethylene film (plastic bag material) is an ideal material for this discovery because it does not appear to be constructed of chains to the casual observer. However, during production, the polyethylene is blown or extruded into thin films while it is above its crystallization temperature (still flowing) aligning the polymer chains that are trapped in this alignment as the film cools. Evidence of this alignment can be seen upon close inspection of a plastic bag as grains or streaks running in one direction. These directional lines are referred to as extrusion lines. It requires almost twice the force to break the material when pulled in the same direction as the extrusion lines vs. perpendicular to the extrusion lines. However, the material exhibits far less strain or deformation before breaking when pulled in the parallel direction vs. perpendicular. This being caused from the breaking of the molecular chains compared to separating them from each other. While the covalent bonds of the chains are eventually broken when pulled in either direction, far more chains are broken at one time in the parallel direction compared to a gradual breaking of the chains as they are separated, allowing a far higher percentage of elongation, while being pulled in the perpendicular direction. The students should see that it is important for the manufacturers to produce the bags so that the extrusion lines are running from the handles down, giving the bag more *strength* vertically yet more *stretch* horizontally.

In order to promote this discovery, teams of students are all given the same type of shopping bag, and instruction on how to test the tensile strength and strain of the bag using easily obtainable materials (i.e. juice jugs, C clamps, shopping bags, etc…). However, they are NOT given any instruction about the extrusion direction and its effect on the tensile strength and strain of the material. When the teams share their data with the class, the students should see that there are inconsistencies in the class data. With a teacher lead discussion the students will learn that the tensile strength and strain depend on the direction they cut the plastic in relation to the extrusion lines, and ultimately to the molecular structure.

Once the students understand the importance of the direction the samples are cut from the bags, and how to test tensile strength vs. strain, they are now ready to design their own experiment to compare the strength of a bag produced with recycled polyethylene with that of a bag composed with no recycled material. The bags produced using recycled material will typically exhibit less tensile strength than those produced with no recycled material due to degradation in the properties of the recycled polyethylene.

To help with grading, the student teams will present their findings to the class, and be graded with the presentation rubric.

This is a guided inquiry lesson that attempts to allow the students to discover through a structured lesson, and then apply what they learned to design their own experiment.

Lesson Sequence (based on 50 minute periods)

Day 1: Pre assessment and Introduction to polymers

Day 2: Tensile strength of polyethylene film experiment

Day 3: The stress of a recycled bag experiment

Day 4: Work on presentations

Day 5: Presentations and post assessment