The Tensile Strength of Polyethylene Film

I. Background: The plastic shopping bag is a product made from the most widely produced polymer in the world - polyethylene. Polyethylene's molecular formula is CH_3-(C_2H_2)n-CH_3 and it is produced with different values of n and degrees of branching which affects the degree of crystalline structure. These difference produces compounds with a range of relative densities by which they are named. The two most common are high density polyethylene HDPE and low density polyethylene LDPE. Most plastic shopping bags are made with the HDPE.

The strength of a material is commonly determined by finding its tensile strength or the force needed to pull the material apart. When conducting a tensile test, samples are typically cut into a "dog-bone" shape, one end is fixed and the other end pulled with increasing force until the sample breaks apart. The shape of the sample is important to insure that the sample breaks across the center, making the method of attachment of no consequence. Tensile strength is measured in force/cross-sectional area – allowing one to make accurate comparisons of different samples. In order to do this, one needs to either calculate the cross-sectional area or use the same cross-sectional area for each sample being tested. Plastic bags represent a film of fairly uniform thickness, allowing an accurate "gauge" to be used by merely cutting the film samples to a uniform width creating a narrowest point along the sample. The gauge will have the smallest cross-sectional area and should be the point at which the samples break.

It is also useful to know the amount of deformation a material will undergo during a tensile test. This is known as strain, and is calculated as the change in the length of a portion of the sample divided by the original length. In this experiment the tensile strength (stress) and strain will be determined for a plastic shopping bag.

II. Experimental Question: What is the tensile strength and strain of a plastic shopping bag?

III. Materials:

Plastic shopping bag	5 gallon bucket	100 ml graduated cylinder
Marker	Ring stand	Plastic Jug (with handle)
Scissors	Utility clamp	600 ml (or larger) beaker
Ruler	C clamp	

IV. Procedure:

Cut out sample pieces:

1. Obtain a plastic shopping bag. Lay it out flat and carefully draw three 3cm x 15 cm rectangles.
2. On each of the rectangles draw two lines across the 3cm width - one 5cm above, and one below the center. These marks will be used to measure the amount of deformation or strain.
3. Cut out the three rectangular pieces of plastic.

Cut each sample piece into a uniform gauge:

4. Fold each piece of plastic at the center so that the two lines overlap.
5. Make two marks at the center of the folded plastic each 0.5 cm from the edge and cut from each of these marks to the edge of the 5cm marks made above. (See Figure 1 below.)

Figure 1: Folded rectangle sample with center cut to 2cm

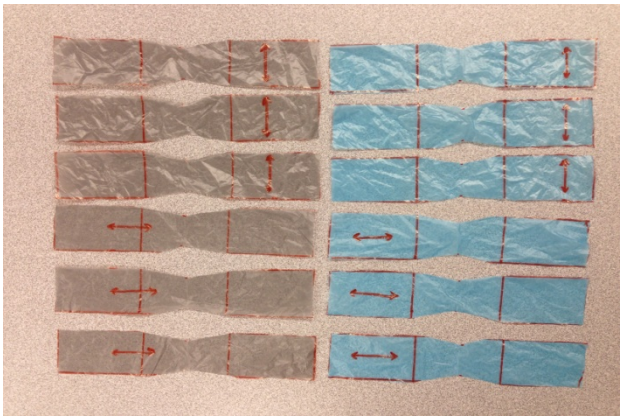

Figure 2: Example of samples cut to 2cm gauge

Test each sample piece for tensile strength and strain:

6. Clamp one end of the plastic sample to the utility clamp mounted on the ring stand.
7. Position the ring stand so that the plastic sample is hanging over the edge of the table.
8. Clamp the bottom edge of the sample to the handle of the juice jug using a C-clamp. (Note: if area of attachment of either end is narrower than the 2 cm gauge, fold the clamped ends of the plastic to increase the area of attachment of both ends. See Fig. 3 below.)

Figure 3: Note the set up, and that the sample is folded under the clamp.

9. Place a five gallon bucket under the plastic jug to catch the jug when the plastic sample breaks.
10. Measure and record the initial distance between the two lines previously made on the sample being tested.
11. Fill a one liter container with water.
12. Slowly add water 100 ml at a time using a graduated cylinder. Measure the length between the two lines after each 100 ml interval.
13. Repeat the addition of water at 100 ml and record the distance between the lines after each of the intervals until the plastic sample breaks.
14. Repeat the test for each of the three samples.

V. Data Table:

Make a table, in the space below, for the data collected from each of the three samples tested. The data table should include the distance between the two lines on the plastic sample for each 100 ml increase in water added.

VI. Calculations:

In the space below, calculate the average tensile strength in grams and the average strain from the three trials.

Use the mass of the juice jug, clamp, and the density of water (1.0 g/ml) to determine the total mass for each trial. Use the equation: final length – initial length/ initial length and determine the strain values. Report the groups finding on the board for class discussion.

VII. Conclusions:

After analysis of class data during class discussion, write a conclusion about the experiment.