

Module Title: Plastic Stretch		
Lab compiled by: Tom Stoebe, MatEd Partner	Address:	Email: tgstoebe@earthlink.net
Time to complete module: 5-10 minutes		
Description of module, lab or demonstration: Through this in-class demonstration, students will be able to effectively observe several material science related concepts associated with polymers. One such observation will be the transformation from the random entanglement of molecules to the crystalline form-evident from the streaks which will become visible in the direction of the applied force. Also, students will be able view "necking" a common side effect of plastic deformation from an applied tensile force (pulling force).		
Pre-requisite knowledge and skills: Although it is not required because of the simplicity of the lab, it may be useful if students have a general understanding of polymers, crystallinity, and tensile testing.		
Materials Category:	Structure of Materials	<input checked="" type="checkbox"/>
	Metals	<input type="checkbox"/>
	Ceramics	<input type="checkbox"/>
	Polymers	<input checked="" type="checkbox"/>
	Composites	<input type="checkbox"/>
	Other	<input type="checkbox"/>
Target Grade Level(s) (Check all that apply)	Middle School 6-8	<input checked="" type="checkbox"/>
	High School 9-12	<input checked="" type="checkbox"/>
	Two-year College 13-14	<input checked="" type="checkbox"/>
	Four-year College 15-16	<input checked="" type="checkbox"/>
MatEd core competencies that the training meets: <ul style="list-style-type: none"> • 7.005 Describe the general nature of plastics • 16.007 Describe how changes in manufacturing processes effect material properties 		
List of equipment and supplies needed: <ul style="list-style-type: none"> • Polyethylene sheet (available from a local hardware store) or a large plastic back (see instructor notes) • Scissors • 30- safety glasses (PPE) • Optional further study: Fish scale 		
Curriculum overview and notes to instructor:	Polyethylene consists of long-chain molecules which are randomly located in the plastic material. When it is stretched, the molecules move so that they become more and more aligned in the direction in which they are being pulled. (An example is spaghetti being boiled in a pot: The spaghetti "molecules" are tangled up but if you put in a	

	<p>fork, you can align them). Sufficient stretching causes a nearly complete alignment, and when this happens in polyethylene, the material forms a neck, and the neck propagates through the material. The neck area is nearly crystalline, that is, it has sufficient alignment of the molecules that the x-ray diffraction pattern shows long range order. The development of the crystalline alignment also increases the strength, since the crystalline polymer is stronger than the non-crystalline material. The un-stretched polyethylene is mostly random and thus not crystalline.</p> <p>Making the "dog bone" specimens, can be done with scissors. Try to make the center section as straight as possible. Flaws in the straight section will cause premature failure (that is part of the demonstration as well). Leave large sections at the ends to hold on to when stretching the plastic. The thicker the polyethylene, the stronger it is and the more force is needed to stretch. A piece with a straight section 2 inches wide and 2 ft. long will elongate about 5 to 8 feet, and the effect is easily seen by a whole class. Smaller sections also work.</p>
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Mode of presentation: Laboratory or Demonstration

<p>Module</p>	<p>Experimental Process</p> <ol style="list-style-type: none"> 1. Choose a team of students or adults for the stretching process. 2. Measure the length of the dog bone area of the specimen 3. Give careful instructions to: <ul style="list-style-type: none"> • Pull slowly and steadily • Be patient, don't rush • Once necking is observed, keep pulling to failure • Measure the final length of the dog bone area of the specimen 4. If the specimen fails, try again with another specimen 5. Once a specimen fails without necking, discuss what could have gone wrong-discuss the effects of defects in the material or in the preparation that effect properties 6. Once a necked specimen is obtained, examine the necked area and note the differences between the necked and original material 7. Calculate the percentage of elongation (change of length/original length) 8. Note and discuss the strength of the material before and after necking
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	<p>9. Discuss why polyethylene is called a "plastic"?</p> <p>Further Study</p> <ol style="list-style-type: none"> 1. Investigate the structure of polyethylene; explain the structure of crystalline vs. non-crystalline polyethylene 2. Find references that talk about necking in metals, and research the difference in necking between plastics and metals 3. Find information on what kinds of defects affect the strength of materials 4. Using a fish scale, graph force required to stretch the polymer
References:	<p>Polymer Science Learning Center, University of Southern Mississippi. (2005). <i>The macrogalleria</i>. Retrieved August 19, 2007, from http://www.pslc.ws/mactest/maindir.htm</p> <p>Olley, R.H. (April 2002). <i>The story of polyethylene</i>. Retrieved August 19, 2007 from, http://www.personal.rdg.ac.uk/~spsolley/pe.html</p> <p>Polymer Science Learning Center, University of Southern Mississippi. (2005). <i>Polyethylene</i>. Retrieved August 19, 2007 from, http://www.pslc.ws/mactest/pe.htm</p>
Briefly describe how the effectiveness of the module was evaluated:	<p>"10 Simple and Effective In-class Experiments and Demonstration for Materials Education" - Ryan A. Webster, Intern-Edmonds Community College</p>
Author Bio:	<p>Dr. Tom Stoebe works with the National Resource Center for Materials Technology Education (MatEd) housed at Edmonds Community College. Dr. Stoebe is a Professor Emeritus in Materials Science and Engineering at the University of Washington and has been at the forefront of materials education in the United States.</p>