

Lab: Successive Heat and Cool Cycles in a Thermoplastic Polymers

Purpose:

In today's experiment we will use a rudimentary extrusion device (hot glue gun) to successively heat and cool a thermoplastic material while testing its **viscosity** to see if these temperature cycles change the polymer. Our aim is to see if the viscosity of the polymer changes by more than 5% with three heat and cool cycles.

Introduction:

Polymers can either be **thermoset**, meaning that the polymer must be molded and shaped before it is cross linked because once formed it cannot be heated and melt, or **thermoplastic** which can be heated and melt after the polymer is formed. The glue used in a hot glue gun is a thermoplastic polymer called EVA or ethylene vinyl acetate copolymer. You can capture the glue in a mold made from a piece of tubing, allow it to cool and melt it again. Ideally, the heating and cooling cycles can be repeated many times without changing the polymer, but since these heating and cooling cycles lengthen and shorten polymer chains properties of the polymer can be affected.

Safety:

- Safety goggles must be worn at all times during the lab.
- The glue gun and melted glue are really hot! Be careful not to touch the metal end of the glue gun or the melted glue until it is cloudy and cool.
- If students prepare the tubing mold, the use of the exacto knife requires caution.

Materials:

- goggles
- mini glue gun and 12 mini glue sticks
- 9 plastic tubing sections (1.5 inches long) to be used as molds, slit lengthwise so the hardened glue can be removed from it. (The inside diameter of the tube sections must match the outside diameter of the glue sticks.)
- a balance that weighs to .001 g
- weighing paper

If students are to prepare the tubing molds on their own, replace the tubing sections with:

- a length of plastic tubing (the inside diameter must match the outside diameter of the glue stick)
- sharp scissors
- exacto knife

Procedure:

To Prepare the Plastic Tubing Molds:

1. Cut the tubing into 1.5 inch pieces.
2. Slit each piece of tubing lengthwise.

Using the Hot Glue Gun for Injection Molding:

1. Place a glue stick into the glue gun and allow it to warm up.
2. Using the tubing as a mold, extrude some hot glue into one end, pushing the glue to the center and filling it to the top. Flip the tubing mold over to fill the other end.
CAUTION! Hold the tubing carefully with your thumb and first finger. The tubing will insulate fingers against burns, as long as all the glue goes **inside** the mold. Do not try to remove the polymer from the tubing until it is cloudy and cool.
3. Continue filling molds until all 9 are filled.
4. When the tubes are cooled, the sides of the tubing can be pulled apart and the molded glue stick released.
5. Put 3 molded glue sticks aside on a piece of paper or beaker labeled "1 heat and cool cycle."
6. Repeat step 2 with the other 6 molded glue sticks.
7. When cool put 3 aside labeled "2 heat and cool cycles."
8. Repeat step 2 with the remaining 3 molded glue sticks.
9. When cool label as "3 heat and cool cycles."

Use of the Hot Glue Gun as a Melt Index Viscometer:

You now have 3 sets of glue sticks, molded one, two or three times, plus the original unused glue sticks. We need to see if its physical properties have changed, and will be doing a crude observation of its viscosity to do this. The hot glue gun will be used to melt the glue sticks for a set period of time and the weight of the extracted melt will give us an indication of its viscosity (the higher the mass, the lower the viscosity.)

1. Label a weighing paper "original glue stick" and find its mass.
2. Heat up the glue gun for 2 minutes (it needs to be the same temperature for all trials, this should insure it is at its maximum temperature.)
3. Place one of the unused glue sticks into the glue gun and extrude the glue onto the weighing paper for a predetermined time (1 to 5 seconds). You can practice this ahead of time; basically you want to make sure that you always use the same amount of pressure on the trigger for the same amount of time.
4. Weigh the sample and record.
5. Repeat the procedure with the unused glue stick for a minimum of 5 trials.
6. Repeat the steps 1 – 5 with the polymer heated and molded 1, 2 and 3 times.

Name _____

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Data:

Mass of Polymer Extruded in _____ Seconds (g)

| Polymer | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Average |
|----------------------|---------|---------|---------|---------|---------|---------|
| Original Glue stick | | | | | | |
| Glue stick molded 1X | | | | | | |
| Glue stick molded 2X | | | | | | |
| Glue stick molded 3X | | | | | | |

Questions:

1. Did the viscosity of the EVA change with repeated heating and cooling? How can you tell?

2. If it did change, determine the percentage of change between the original glue stick and the glue stick that underwent 3 heating and cooling cycles. Did it change more than 5%?

3. Discuss sources of error in this experiment.



