HDPE JUG/HEAT GUN DEMONSTRATION

GOALS/PURPOSE

- Investigate plastic properties at elevated temperatures
- Show polymer memory by heating and shrinking a PETE bottle

MATERIALS/EQUIPMENT

- HDPE plastic jug (#2 recycling code)—distilled water, milk or orange juice jug (rinsed and dried)
- PETE plastic bottle (#1 recycling code)—16 oz. soda bottle, half full of water
- Plastic preform
- Heat gun (sold as a paint stripper at Walmart, hardware stores or home improvement stores)
- Extension cord (if needed)

SAFETY

- Make sure the HDPE jug is dry before starting the demonstration to avoid steam burns when blowing air into the heated jug.

PROCEDURE

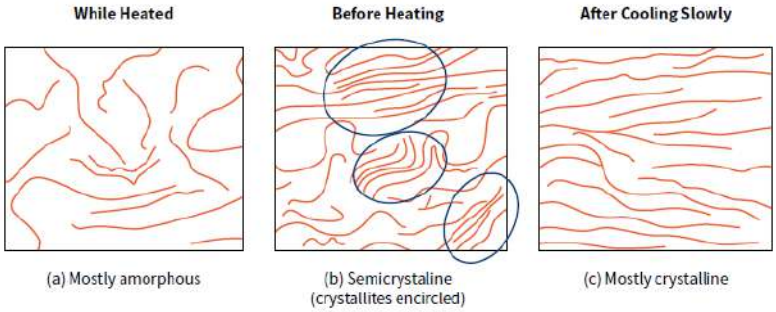

Fig. 4.5 *As the HDPE jug cools, polymer chains have time to arrange in a more orderly fashion than they were originally (they have more crystallinity).*

1. Remove the cap or lid and heat the side of the bottle with a heat gun. The polymer chains will start to relax as they gain energy and will lose some of their crystallinity. The heated area will become transparent and softer (flexible).
2. Allow the jug to cool. As it slowly cools the polymer chains have time to arrange in a more orderly fashion than they were originally (have more crystallinity) and the affected area will now appear more opaque than the rest of the jug. When a polymer exhibits crystallinity, it isn't the individual atoms that are arranging into a repeating pattern, it is the molecules themselves (the chains) that exhibit some long-range order.
3. Reheat the jug until the area becomes transparent and flexible again. When it reaches this point, gently blow into the opening of the container (blow molding). The polymer will stretch and expand and take on a new shape. This demonstrates the nature of a thermoplastic.
4. As the jug cools, the stretched area will become less transparent as the chains lose mobility and regain some crystallinity.
5. Half fill a used PETE (soda or water) bottle with water. Do not put the cap or lid back on.
6. Hold the bottom of the bottle with one hand while heating the top half with the heat gun. The water has a high specific heat capacity and will prevent the bottom half of the bottle from being affected by the heat gun.
7. The top half of the bottle will being to shrink back to the size and shape of the original preform from which it was made. Show the students a preform for comparison. This also demonstrates the nature of a thermoplastic.

INSTRUCTOR NOTES

- One method of classifying polymers is by their reaction to heat. The two main categories are **thermoplastics** and **thermosets**.
    1. **Thermoplastics** soften or melt when heated and resolidify when cooled. These are the primary types of polymers used for recycling (HDPE, PETE, etc.) that display the triangular recycling codes.
    2. **Thermosets** are polymers that set permanently into a solid form when made by an exothermic reaction. They cannot be re-softened or melted by heat and therefore are difficult to recycle. They can be shredded and used as fillers in other polymer materials.
- This demonstration uses thermoplastics. A polyurethane thermoset is used in one of the polymer station labs.
- The jug is translucent because the polymer chains are mostly in an amorphous (random) arrangement with some regions of crystallinity (orderly arrangement).
- The more random the chains become in HDPE the more transparent it will appear. As crystallinity increases in HDPE the more opaque it appears.
- The first part of the demonstration involves heating one side of the HDPE jug with the heat gun and observing changes in optical properties. It also demonstrates how heat can be used to change the shape of thermoplastics.
- Drinking bottles, such as soda bottles or water bottles, can also be used to demonstrate properties of thermoplastics. These bottles are made of polyethylene terephthalate (recycling code #1).
- The second part of the demonstration involves shrinking the upper half of a PETE bottle using the heat gun.
- The PETE bottle was formed by heating a preform and then blow molding to expand the preform to bottle shape. Upon heating above the softening temperature the plastic bottle begins to return to the shape of the original preform (a form of polymer memory).