Thermoformable Polymers

Although we generally consider the words "plastics" and "polymers" interchangeable, the term "plastics" refers to the product delivered as resin pellets or sheet. Nearly all plastics contain "polymers," the pure long-chain hydrocarbons, but they also contain shopping lists of additives such as thermal stabilizers, antioxidants, color correcting dyes, internal and external processing aids, as well as product-specific additives such as fire retardants, colorants, UV stabilizers and fillers. However, because the term "plastic" connotes cheapness and poor quality, the industry is now calling all polymeric materials "polymers."

There are two general categories of polymers. When the polymer can be heated and shaped many times without substantial change in its characteristic, it is a "thermoplastic." When the polymer cannot be reshaped after being heated and shaped the first time, it is a "thermoset." Thermoforming is primarily concerned with thermoplastics.

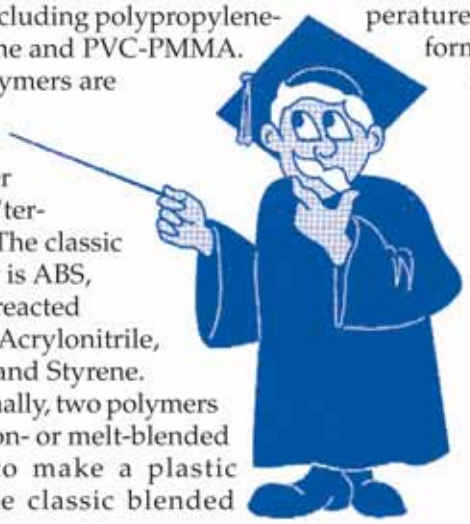
Thermoformers use two general types of polymers. When a polymer is heated from very low temperature, it undergoes a transition from its glassy state to a rubbery state. Although this transition occurs over several degrees of temperature, usually only one temperature value is reported as the "glass transition temperature." Polymers that only have a glass transition temperature are called "amorphous polymers." Polystyrene, ABS, PVC and polycarbonate are examples of amorphous polymers. 80% of all polymers thermoformed are amorphous polymers. 80% of all amorphous polymers are styrenic, that is, polystyrene, impact polystyrene, ABS, and other similar polymers.

Certain polymers exhibit a second transition, from the rubbery state to a molten or melt state. Again, this transition occurs over several degrees of temperature, and again usually only one temperature value is reported as the "melt temperature." Polymers that have both glass transition and melt temperatures are called "crystalline polymers." Polyethylene and polypropylene are examples of crystalline polymers.

If only one polymer is used in a given plastic recipe, the polymer is called a "homopolymer." Examples of homopolymers include general purpose polystyrene [GPPS or sometimes called "crystal polystyrene" because parts made of the unpigmented water-white polymer have the appearance of fine crystal], low-density polyethylene or LDPE and polyethylene terephthalate or PET. If one polymer is reacted with another, the polymer is called a "copolymer." Impact polystyrene or HIPS is an example of polystyrene reacted with a rubber such as butadiene. Many copolymers are used in thermoforming, including polypropylene-polyethylene and PVC-PMMA. If three polymers are reacted together, the polymer is called a "terpolymer." The classic terpolymer is ABS, which is a reacted product of Acrylonitrile, Butadiene and Styrene.

Occasionally, two polymers are extrusion- or melt-blended together to make a plastic recipe. The classic blended polymer is modified polyphenylene oxide or mPPO, which is a near-equal blend of polystyrene and polyphenylene oxide. mPPO is desired for its good impact resistance and fire retardancy.

The "thermoforming window" is the temperature range over which the polymer is sufficiently subtle or deformable for stretching and shaping into the desired shape. Typically, amorphous polymers have broader thermoforming windows than crystalline polymers. Polystyrene, for example, can be formed from around 260°F or about 50°F above its glass transition temperature to about 360°F or only a few degrees below the temperature where it is injection moldable. Polypropylene homopolymer, on the other hand, is so fluid above its melting temperature of 330°F that its thermoforming window may be no more than one degree or so. As a result, it is frequently formed just below its melting temperature. Even then, its thermoforming window may be only two or three degrees.



Keywords: amorphous, crystalline, glass transition temperature, melting temperature, homopolymer, copolymer, terpolymer, blend, thermoforming window

[This is one in a series of articles introducing general concepts in thermoforming.]