8.6

Polycarbonate (PC)

This class of engineering thermoplastic resins differs from all the others discussed so far in that only one type of polycarbonate has reached significant commercial success. Therefore, the properties of the class and the properties of the individual polymer are the same.

Brand names commonly associated with polycarbonates include GE's Lexan® and Bayer's Merion®. **Polycarbonate** is formed by a condensation polymerization resulting in a carbon that is bonded to three oxygens, a characteristic of carbonates. The polymer repeating unit for polycarbonate is shown in Figure 8.6.

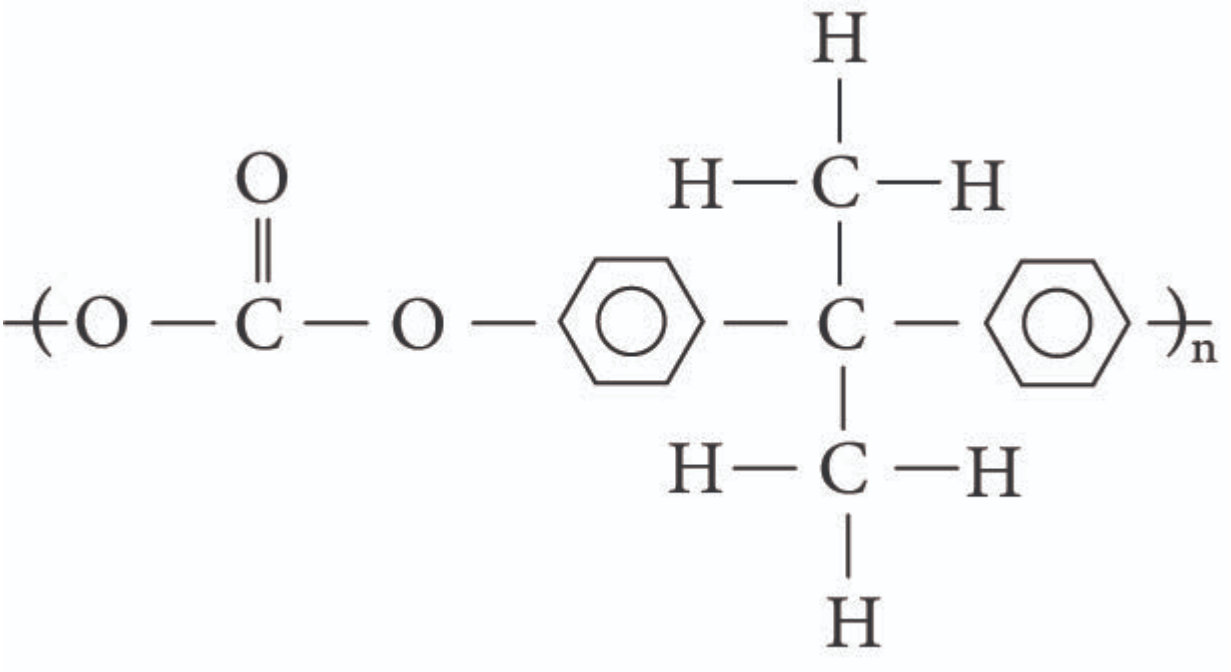


Figure 8.6 Polymer repeating unit for polycarbonate (PC).

The large, complex, aromatic structure of polycarbonate determines the physical and mechanical properties of the molecule. Polycarbonate is non-crystalline and therefore clear, yet is nearly as strong as the highly crystalline nylon and acetal plastics and is somewhat tougher. This mechanical performance is due to the large aromatic content of the polymer, leading to backbone stiffness coupled with moderately large pendant groups and the hydrogen bonds that can form between the polar carbonates on adjacent molecules. All these factors increase the resistance to intermolecular movement that is needed for high strength.

The same factors that give strength also increase the energy needed to cause melting. In the case of polycarbonate, the melting (softening) point and the use temperature are much higher than for the competitive nylon, acetal, and TP polyester materials. (Polycarbonate can be used continuously to 275°F, 135°C.) Creep resistance over an exceptionally wide temperature range and other factors contributing to dimensional stability are important polycarbonate properties. These properties are also contributed by the high aromatic content, pendant groups, and hydrogen bonding.

Impact toughness depends upon the ability of the material to absorb and distribute localized energy. To do that effectively, the material must have strength so that it won't break and, simultaneously, sufficient resilience or elongation that the force can be transferred throughout the structure. Polycarbonate has the strength, as already described, and also has the resilience because of its interconnected (with hydrogen bonds) yet amorphous structure. All these superior mechanical and physical properties have created a strong application capability for polycarbonate. Uses include small tool housings, hot-dish handles, hair dryers, camera bodies, pump impellers, safety helmets, business machine housings, and recreational vehicle bodies. Polycarbonate competes with nylon, acetal, and TP polyesters for these markets. Several polycarbonate products are shown in Photo 8.6.




BELL



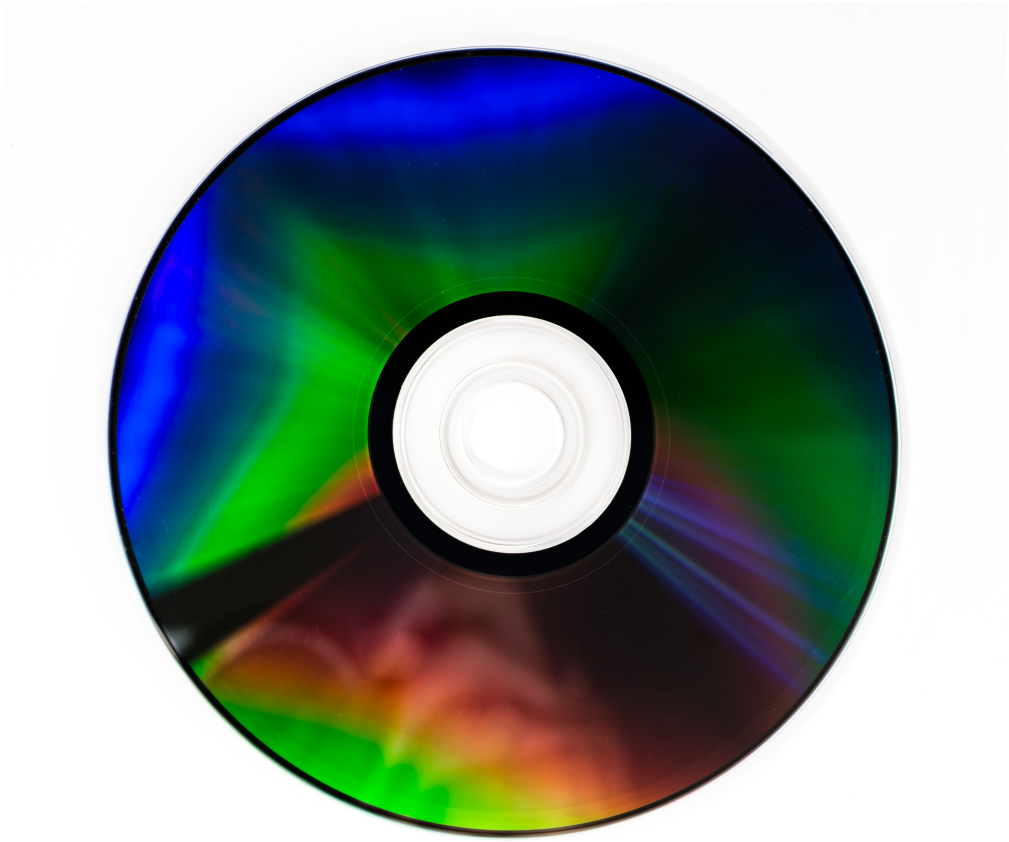


Photo 8.6 Various polycarbonate (PC) products. (a) Impact-resistant bottle. (b) PC safety helmet. (c) PC eye-wear. (d) PC compact discs. (Courtesy of BYU)

The combination of high optical clarity and toughness is unique to polycarbonate. These properties have led to applications such as small appliance housings (especially where temperature is a problem), bulletproof windows, break-resistant lenses, compact discs, food-processing containers and housings, returnable milk bottles, headlights, tail-lights, runway markers, microwave containers, medical tubing connectors, and filter housings. One caution is that polycarbonate is sensitive to UV light. It degrades with some yellowing and loss of mechanical properties. This sensitivity is less than with polystyrene but more than with acrylics, which are discussed later in this chapter. Another drawback of polycarbonate in optical applications is the ease of scratching the surface, but coated grades have been developed to solve this problem.

Polycarbonate is sensitive to aromatic, chlorinated solvents and some polar solvents and has poor resistance to alkali solutions. These solvents can cause crazing and weakness. The advantage of this solvent sensitivity is that polycarbonate can be joined easily with many common solvent-based adhesives.

The polar nature of polycarbonate leads to a modest amount of moisture absorption. This absorptivity is highest and most damaging in the melt; therefore, polycarbonate should be dried before processing.

The high melting temperature causes some difficulties in processing, but polycarbonate is not especially sensitive to thermal degradation, so thinning by raising the temperature is usually an acceptable method of improving processing. Polycarbonates can be processed by extrusion, injection molding, blow molding, thermoforming, and structural foaming.

Polycarbonate can be filled with glass fibers to increase strength, especially for metal replacement applications. Polycarbonate is the basis of numerous blends and alloys that make use of the toughness and strength of polycarbonate and add some other beneficial property from the second polymer.



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