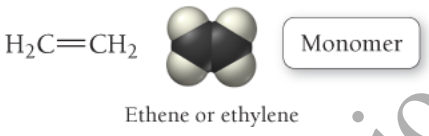
Pearson

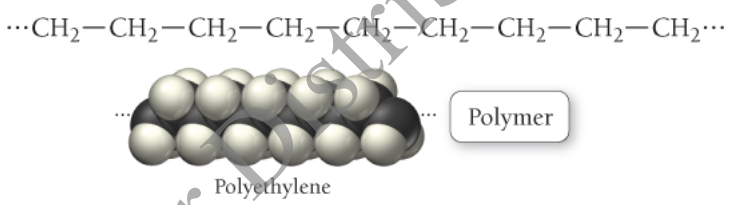
12.9: Polymers and Plastics

Polymers are long, chainlike molecules composed of repeating units called **monomers**. In Chapter 21, we will discuss natural polymers such as starches, proteins, and DNA, which play important roles in living organisms. In this section, we learn about synthetic polymers, which we encounter daily in plastic products such as PVC tubing, styrofoam coffee cups, nylon rope, and plexiglass windows. Polymeric materials are common, found in everything from computers to toys to packaging materials. Most polymers are durable, partly because of the length of their molecules. In general, the longer the length of a molecule, the greater the intermolecular forces between molecules and the higher the melting point and boiling point of the substance. Because breaking or tearing a polymeric material involves either overcoming the intermolecular forces between chains or actually breaking the covalent bonds between monomers, polymers tend to be durable materials.

One of the simplest synthetic polymers is polyethylene. The polyethylene monomer is ethene (also called ethylene):



Ethene monomers react with each other, breaking the double bond between carbons and bonding together to form a long polymer chain:



Polyethylene is an **addition polymer**, a polymer in which the monomers link together without the elimination of any atoms. Polyethylene is the plastic that is used for milk jugs, juice containers, and garbage bags.

The properties of polyethylene depend on the exact structure of the ethylene chain and the resulting structure of the material. Although polymers are generally amorphous, they can have regions of crystallinity. For polyethylene, the degree of crystallinity depends in part on the degree of branching in the chain. *High-density polyethylene* (*HDPE*), for example, has little branching, so that the chains can align more closely to one another, resulting in high crystallinity, high density, and good strength and heat resistance. Common plastic milk jugs are made of HDPE (Figure 12.23). *Low-density polyethylene* (*LDPE*), in contrast, has more highly branched chains. This branching prevents the chains from interacting as efficiently, resulting in lower crystallinity, lower density, and lower strength and heat resistance. Many common plastic bags are made of LDPE.

Figure 12.23 Polyethylene

Plastic milk bottles are made from polyethylene.

Substituted polyethylenes make up an entire class of polymers. For example, polyvinyl chloride (PVC)—the plastic used to make certain kinds of pipes and plumbing fixtures—is composed of monomers in which a chlorine atom has been substituted for one of the hydrogen atoms in ethene (Figure 12.24). These monomers, which are shown here, react to form PVC:

Figure 12.24 Polyvinyl Chloride

Polyvinyl chloride is used for many plastic plumbing supplies, such as pipes and connectors.

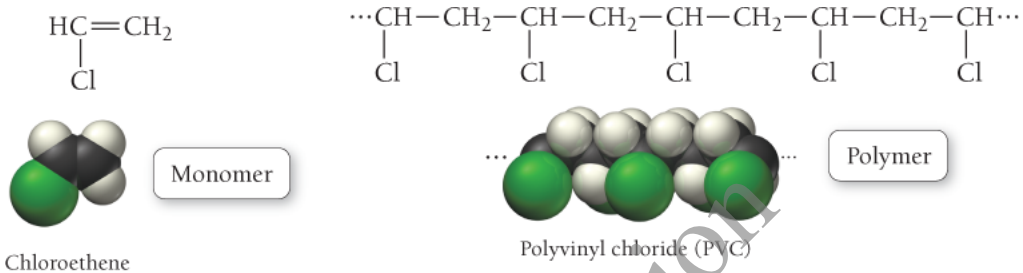
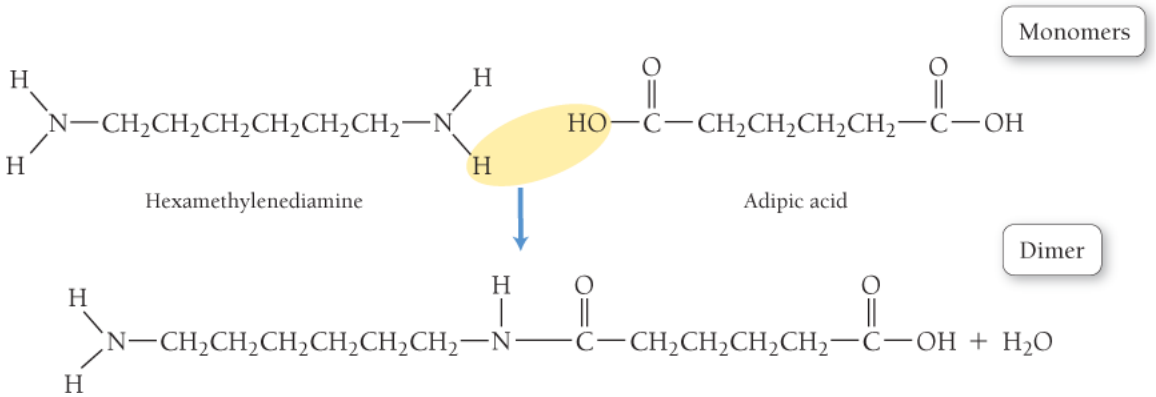


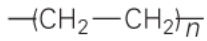
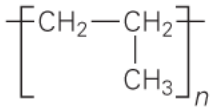
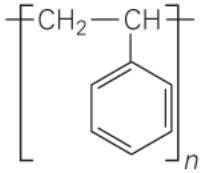
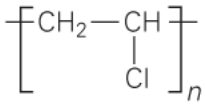
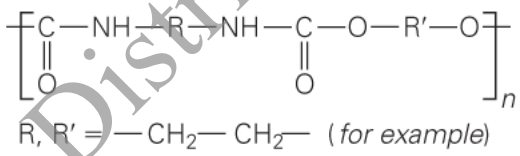
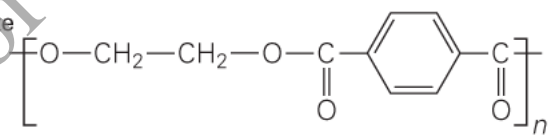
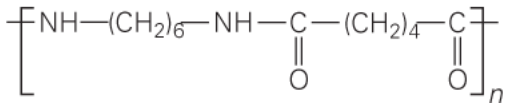
Table 12.2 lists several other substituted polyethylene polymers.

Some polymers—called **copolymers**—consist of two different kinds of monomers. For example, the monomers that compose nylon 6,6 are hexamethylenediamine and adipic acid. These two monomers add together via a condensation reaction as follows:



The product that forms between the reaction of two monomers is a **dimer**. The polymer (nylon 6,6) forms as the dimer continues to add more monomers. Polymers that eliminate an atom or a small group of atoms during polymerization are called **condensation polymers**. The condensation polymer nylon 6,6 and other similar nylons can be drawn into fibers and used to make consumer products such as panty hose, carpet fibers, and fishing line. Table 12.2 shows other condensation polymers.

Table 12.2 Polymers of Commercial Importance

Polymer	Structure	Uses
Addition Polymers		
Polyethylene		Films, packaging, bottles
Polypropylene		Kitchenware, fibers, applianc
Polystyrene		Packaging, disposable food containers, insulation
Polyvinyl chloride		Pipe fittings, clear film for m packaging
Condensation Polymers		
Polyurethane	 R, R′ = —CH_2—CH_2— (*for example*)	"Foam" furniture stuffing, spray-on insulation, automo parts, footwear, water-prote coatings
Polyethylene terephthalate (a polyester)		Tire cord, magnetic tape, apparel, soda bottles
Nylon 6,6		Home furnishings, apparel, carpet fibers, fish line, polyn blends