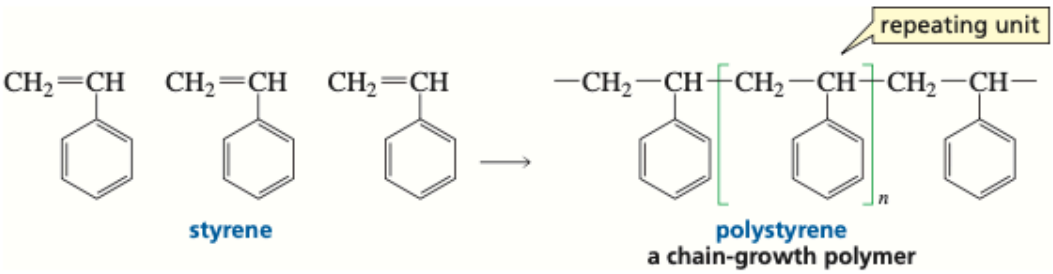
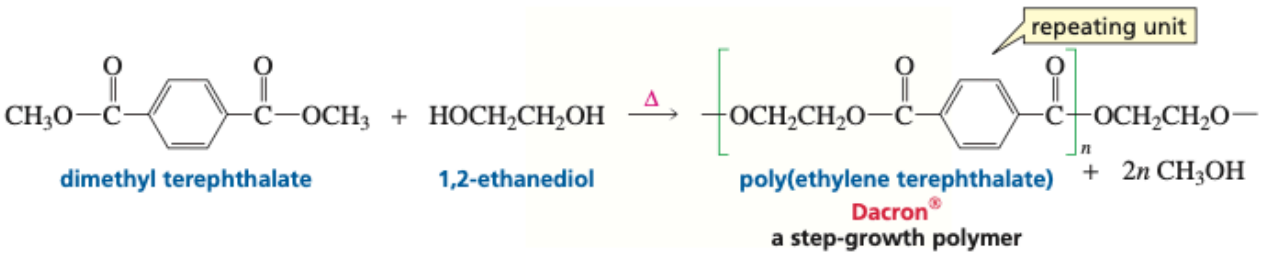
28.1 General Classes of Synthetic Polymers

Synthetic polymers can be divided into two major classes, depending on their method of preparation. **Chain-growth polymers**, also known as **addition polymers**, are made by **chain reactions**—the addition of monomers to the end of a growing chain. The end of the chain is reactive because it is a radical, a cation, or an anion. Polystyrene—used for disposable food containers, insulation, and toothbrush handles, among other things—is an example of a chain-growth polymer. Polystyrene is pumped full of air to produce the material known as Styrofoam®.



Step-growth polymers, also called **condensation polymers**, are made by combining two molecules while, in most cases, removing a small molecule, generally water or an alcohol. The reacting molecules have reactive functional groups at each end. Unlike chain-growth polymerization, which requires the individual molecules to add to the end of a growing chain, step-growth polymerization allows any two reactive molecules to combine. Dacron® is an example of a step-growth polymer.



Dacron® is the most common of the group of polymers known as **polyesters**—polymers with many ester groups. Polyesters are used for clothing and are responsible for the wrinkle-resistant behavior of many fabrics. Polyester is also used to make the plastic film called Mylar®, needed in the manufacture of magnetic recording tape. This film is tear-resistant and, when processed, has a tensile strength nearly as great as that of steel. Aluminized Mylar® was used to make the Echo satellite that was put into orbit around the Earth as a giant reflector. The polymer used to make soft drink bottles is also a polyester.

28.2 Chain-Growth Polymers

The monomers used most commonly in chain-growth polymerization are ethylene (ethene) and substituted ethylenes. In the chemical industry, monosubstituted ethylenes are known as **alpha olefins**. Polymers formed from ethylene or substituted ethylenes are called **vinyl polymers**. Some of the many vinyl polymers synthesized by chain-growth polymerization are listed in Table 28.1.

Chain-growth polymerization proceeds by one of three mechanisms: **radical polymerization**, **cationic polymerization**, or **anionic polymerization**. Each mechanism has three distinct phases: an *initiation step* that starts the polymerization, *propagation steps* that allow the chain to grow, and *termination steps* that stop the growth of the chain. We will see that the choice of mechanism depends on the structure of the monomer *and* the initiator used to activate the monomer.

Table 28.1 Some Important Chain-Growth Polymers and Their Uses

Monomer	Repeating unit	Polymer name	Uses
$CH_2{=}CH_2$	$-CH_2-CH_2-$	polyethylene	film, toys, bottles, plastic bags
$CH_2{=}CH(Cl)$	$-CH_2-CH(Cl)-$	poly(vinyl chloride)	"squeeze" bottles, pipe, siding, flooring
$CH_2{=}CH-CH_3$	$-CH_2-CH(CH_3)-$	polypropylene	molded caps, margarine tubs, indoor/outdoor carpeting, upholstery
$CH_2{=}CH(C_6H_5)$	$-CH_2-CH(C_6H_5)-$	polystyrene	packaging, toys, clear cups, egg cartons, hot drink cups
$CF_2{=}CF_2$	$-CF_2-CF_2-$	poly(tetrafluoroethylene) Teflon®	nonsticking surfaces, liners, cable insulation
$CH_2{=}CH(C{\equiv}N)$	$-CH_2-CH(C{\equiv}N)-$	poly(acrylonitrile) Orlon®, Acrilan®	rugs, blankets, yarn, apparel, simulated fur
$CH_2{=}C(CH_3)(COCH_3{=}O)$	$-CH_2-C(CH_3)(COCH_3{=}O)-$	poly(methyl methacrylate) Plexiglas®, Lucite®	lighting fixtures, signs, solar panels, skylights
$CH_2{=}CH(OCCH_3{=}O)$	$-CH_2-CH(OCCH_3{=}O)-$	poly(vinyl acetate)	latex paints, adhesives