28

Synthetic Polymers

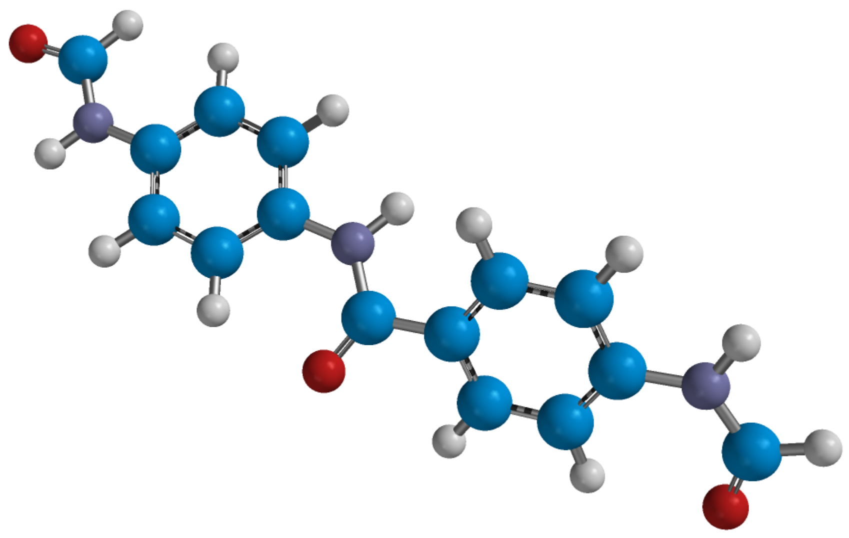


Figure 28.1 London Forces in Polyethylene

The closely packed, all-anti conformation of the alkyl chains results in many London attractive forces.

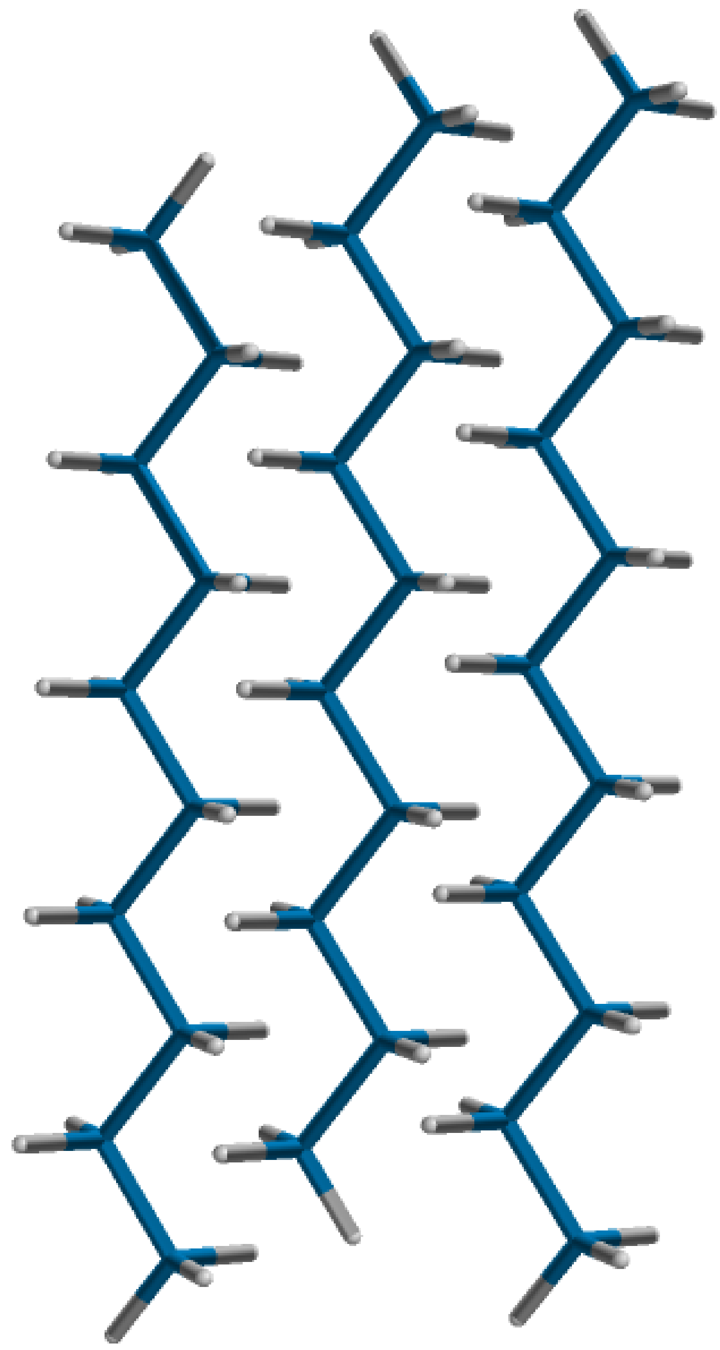


Figure 28.2 Branching in Low-Density Polyethylene

The branched chains of the alkanes prevent close packing, and results in a lower density polymer than polytheylene.

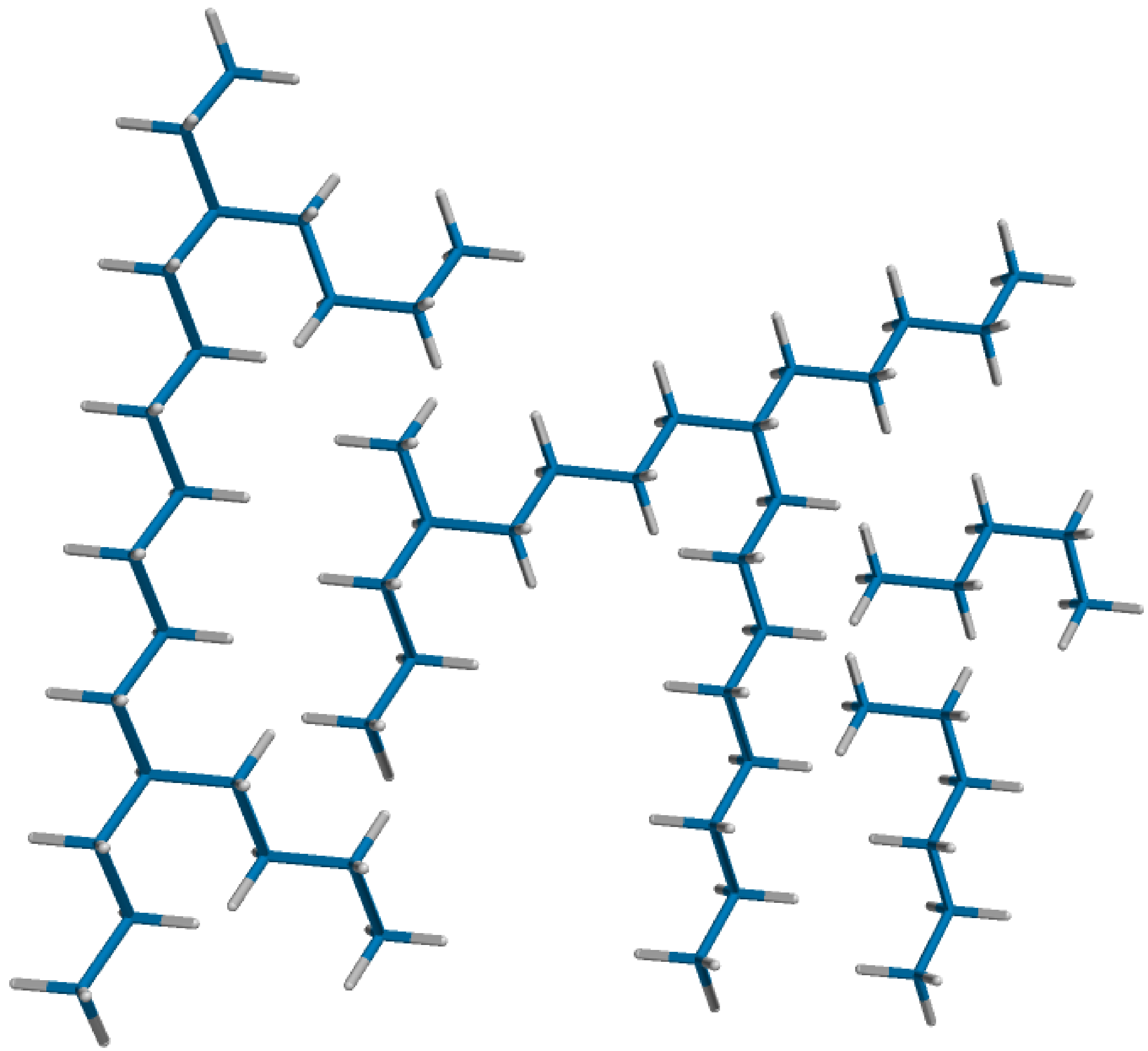


Figure 28.4 Hydrogen Bonding in Nylon 66

In the all-anti conformation, hydrogen bonds form between amide hydrogen atoms and carbonyl oxygen atoms.

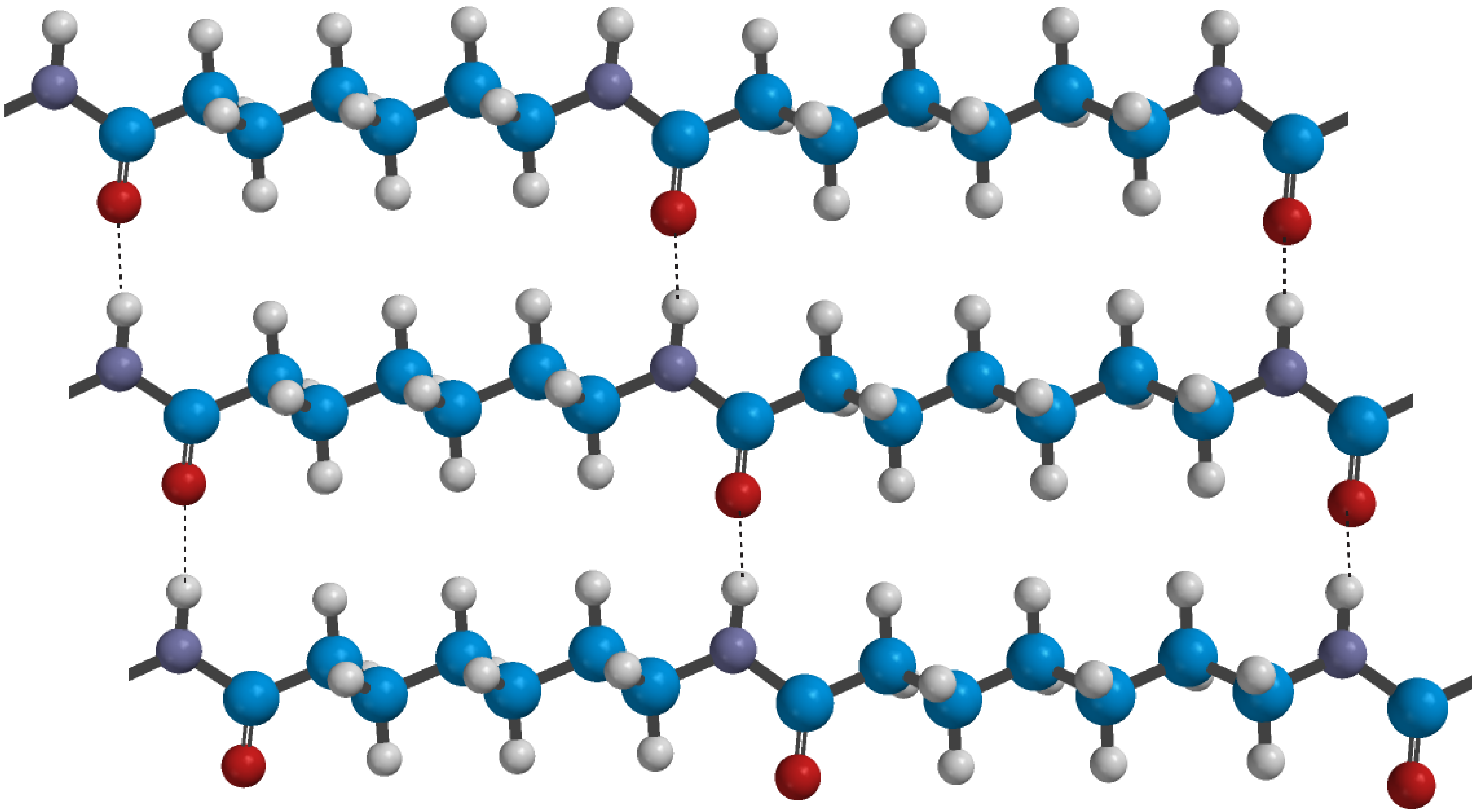


Figure 28.5 Hydrogen Bonding in Kevlar

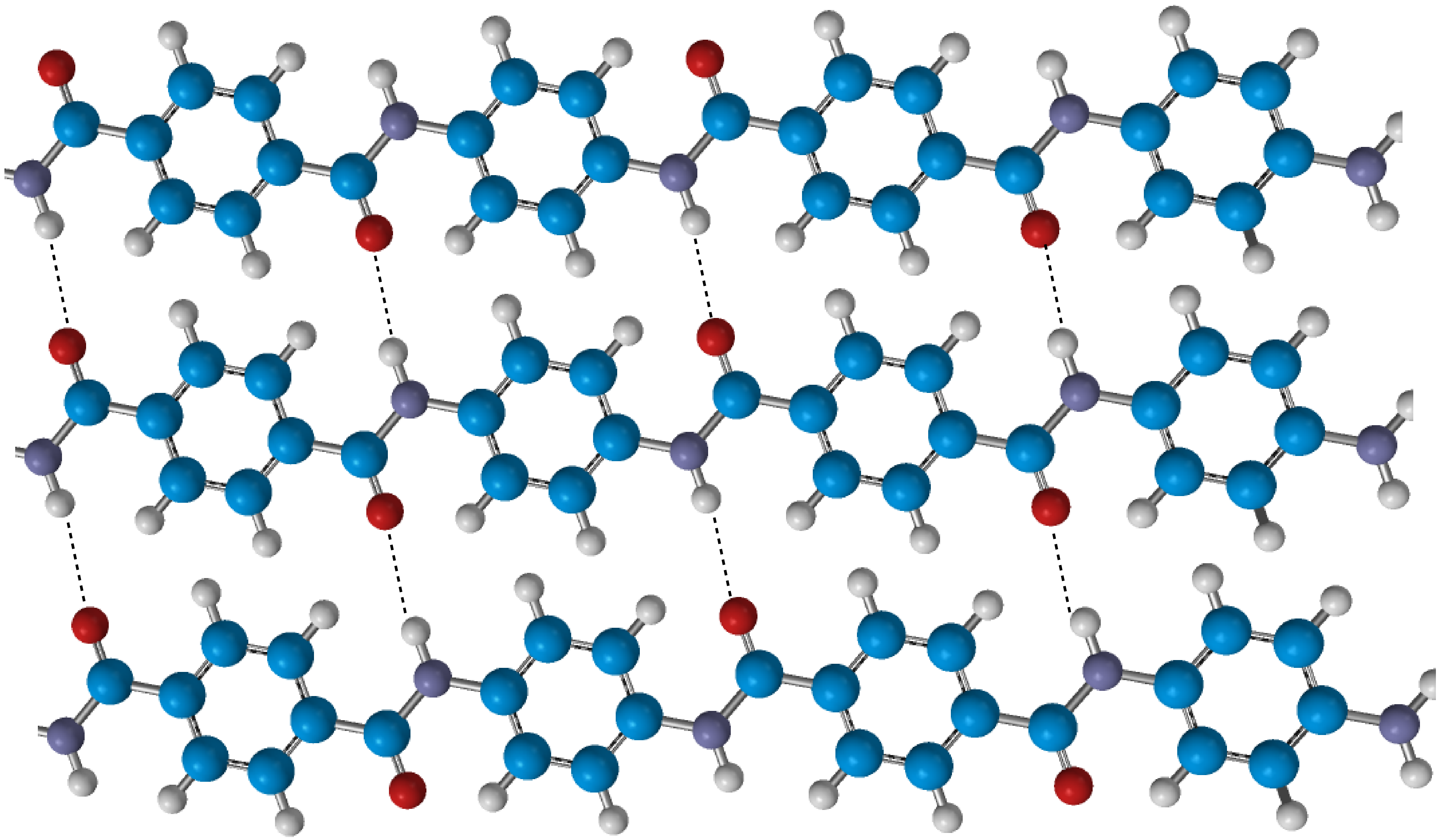


Figure 28.6 Crystallinity in Polymers

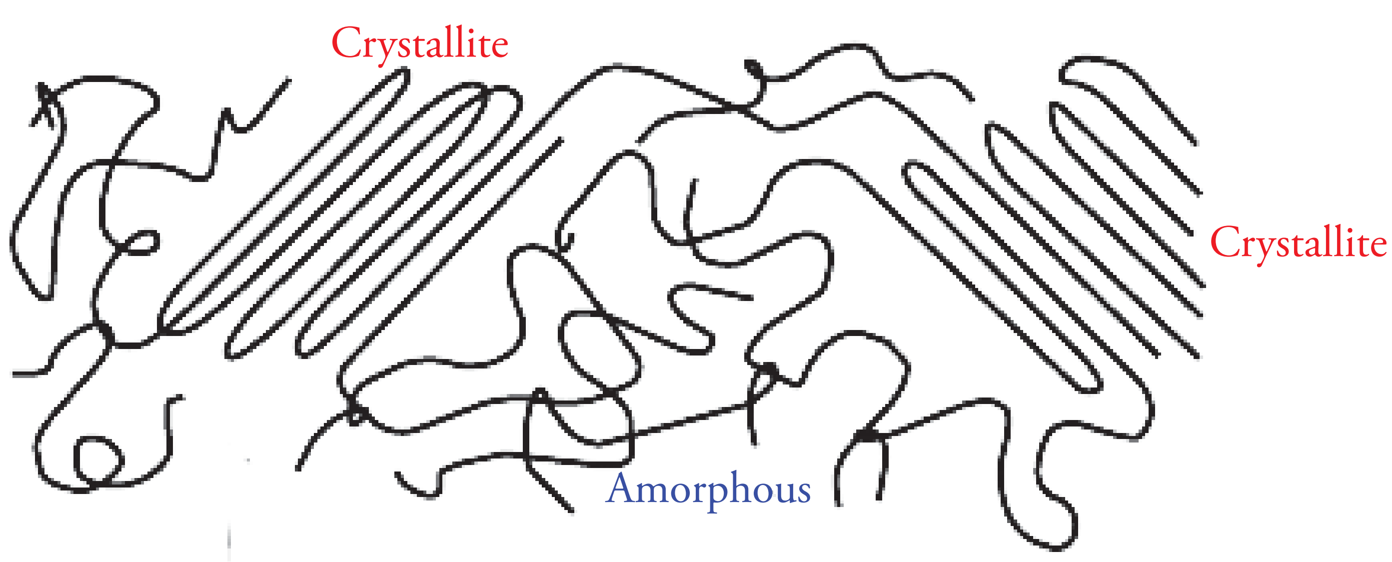
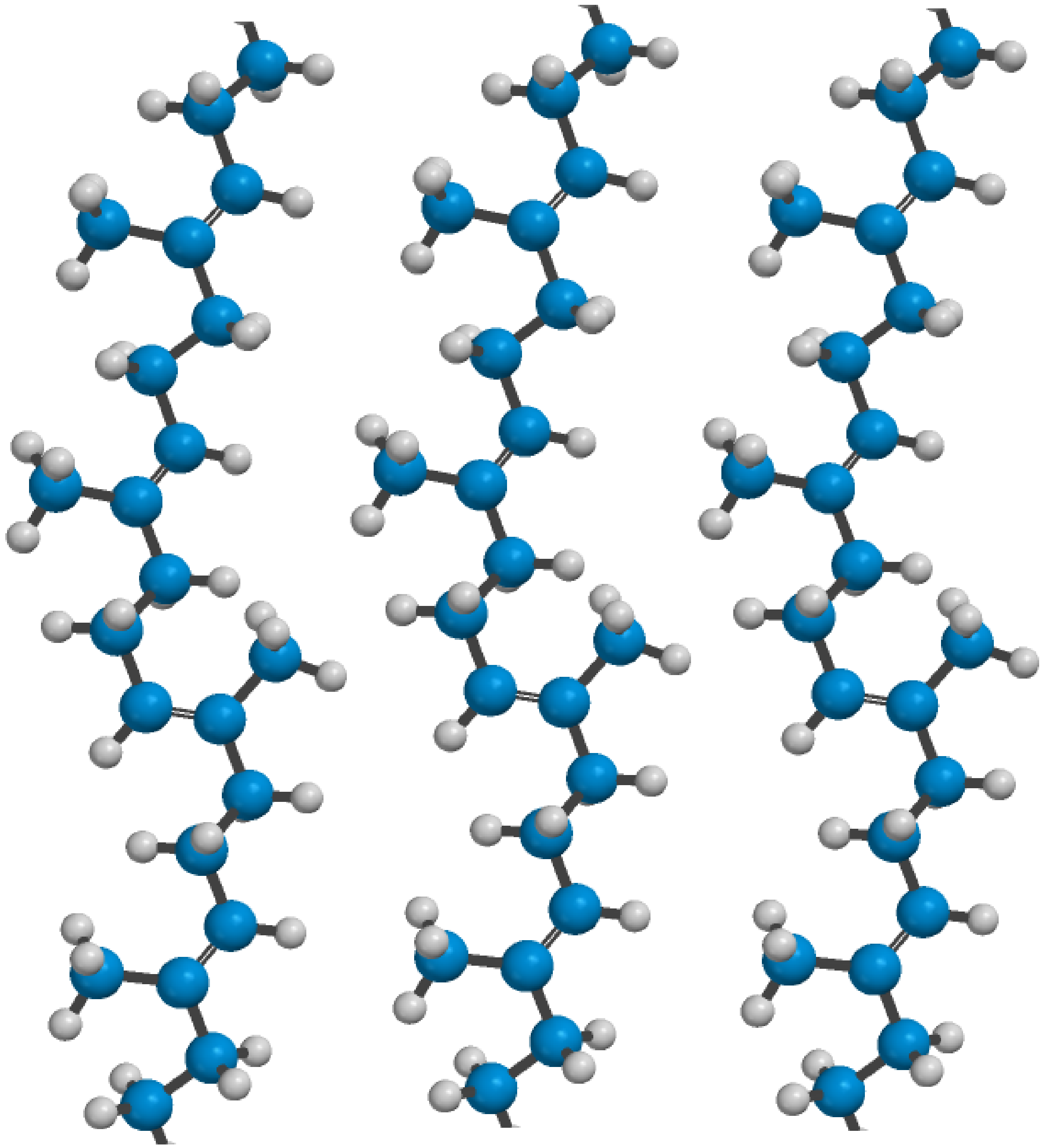
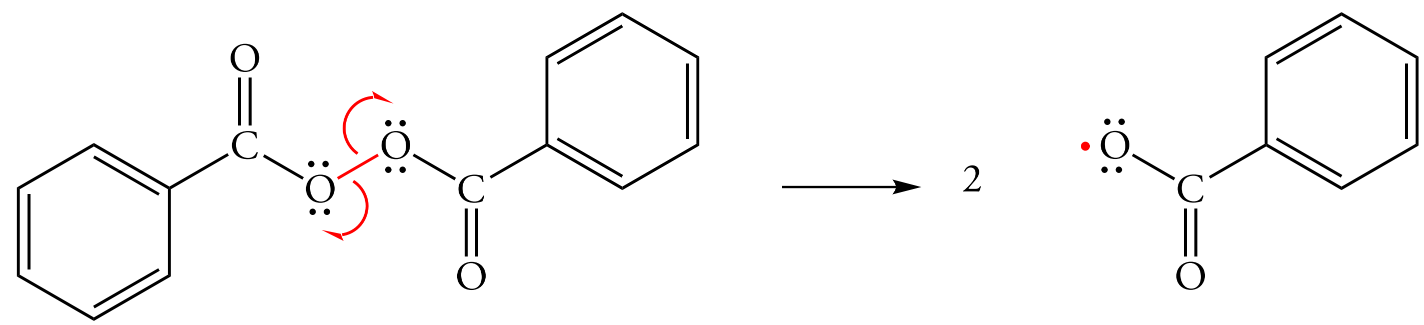


Figure 28.7 Polyisoprene

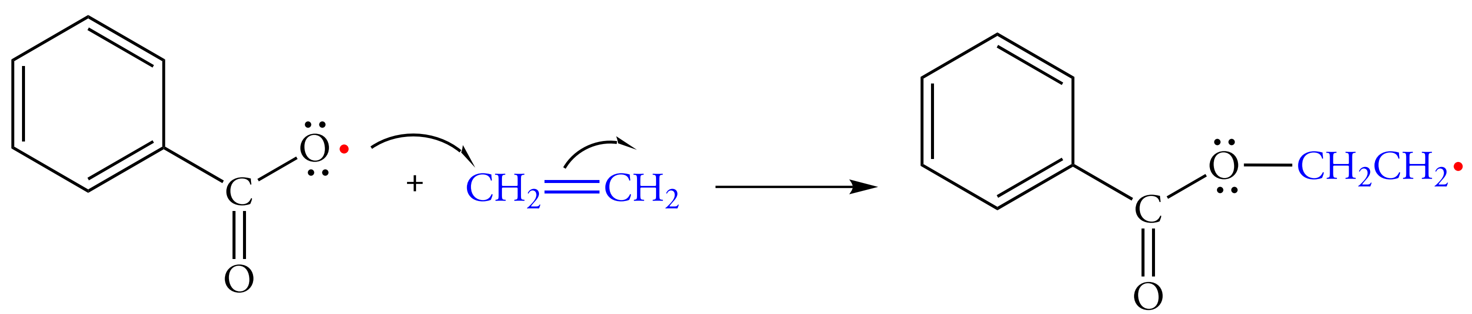
The double bonds in polyisoprene are all *trans*. Rotation around the planar double bonds cannot occur, and the conformations around the σ bonds allow close packing of the polymer chains giving a relatively hard, rigid structure

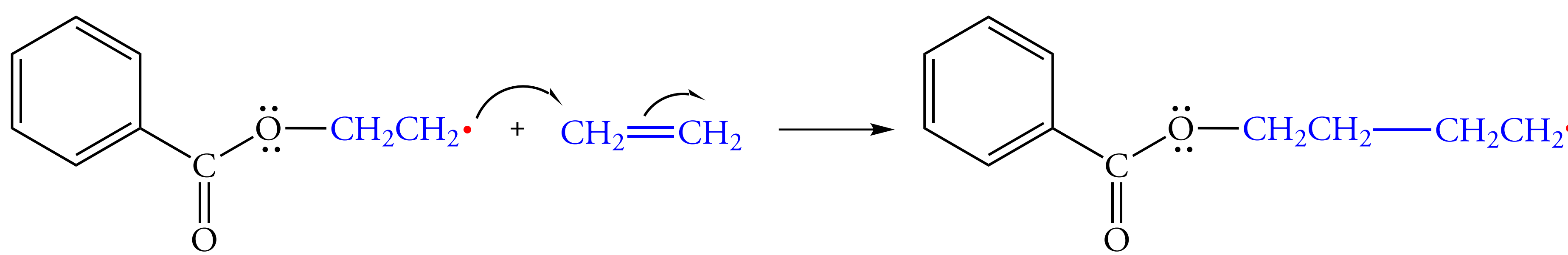


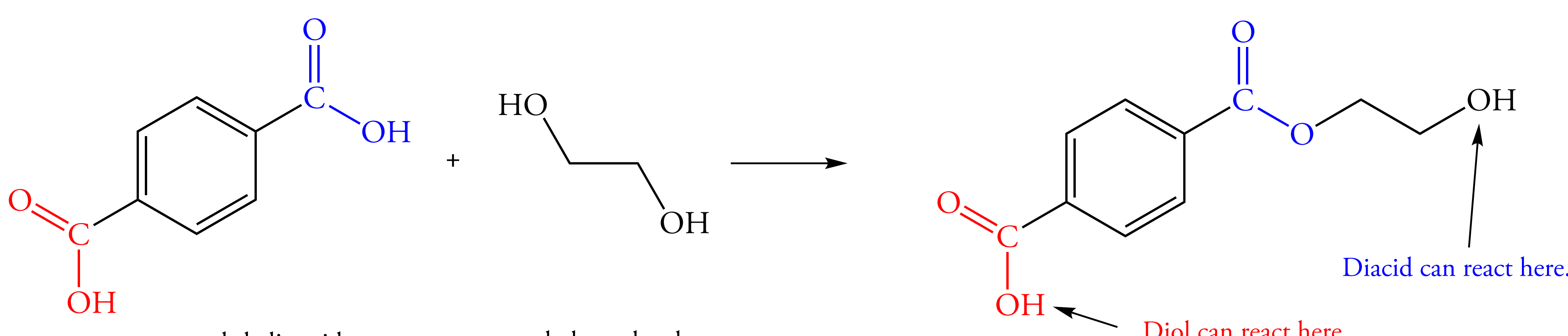
28.4 POLYMERIZATION METHODS



benzoyl peroxide — benzoyl radical







terephthalic acid — ethylene glycol

28.5 ADDITION POLYMERIZATION
Termination Steps

$$2\,R{-}(CH_2CH_2)_nCH_2CH_2\cdot \longrightarrow R{-}(CH_2CH_2)_nCH_2{=}CH_2 + R{-}(CH_2CH_2)_nCH_2{-}H$$

$$2\,R{-}(CH_2CH_2)_nCH_2CH_2\cdot \longrightarrow R{-}(CH_2CH_2)_nCH_2CH_2{-}(CH_2CH_2)_nCH_2{-}R$$

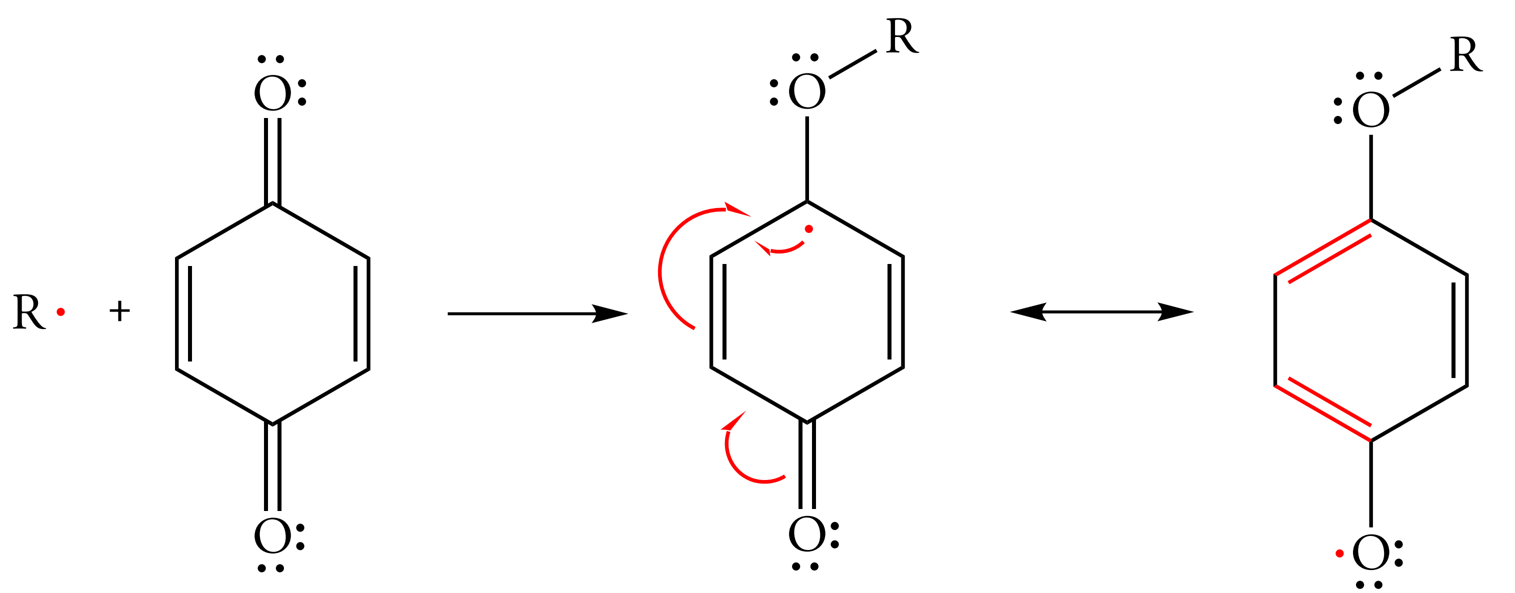
28.5 ADDITION POLYMERIZATION
Regulation of Chain Length

$$2\,R{-}CH_2CH_2\cdot \;+\; R'{-}S{-}H \longrightarrow R{-}CH_2CH_2{-}H \;+\; R'{-}S\cdot$$

a terminated chain

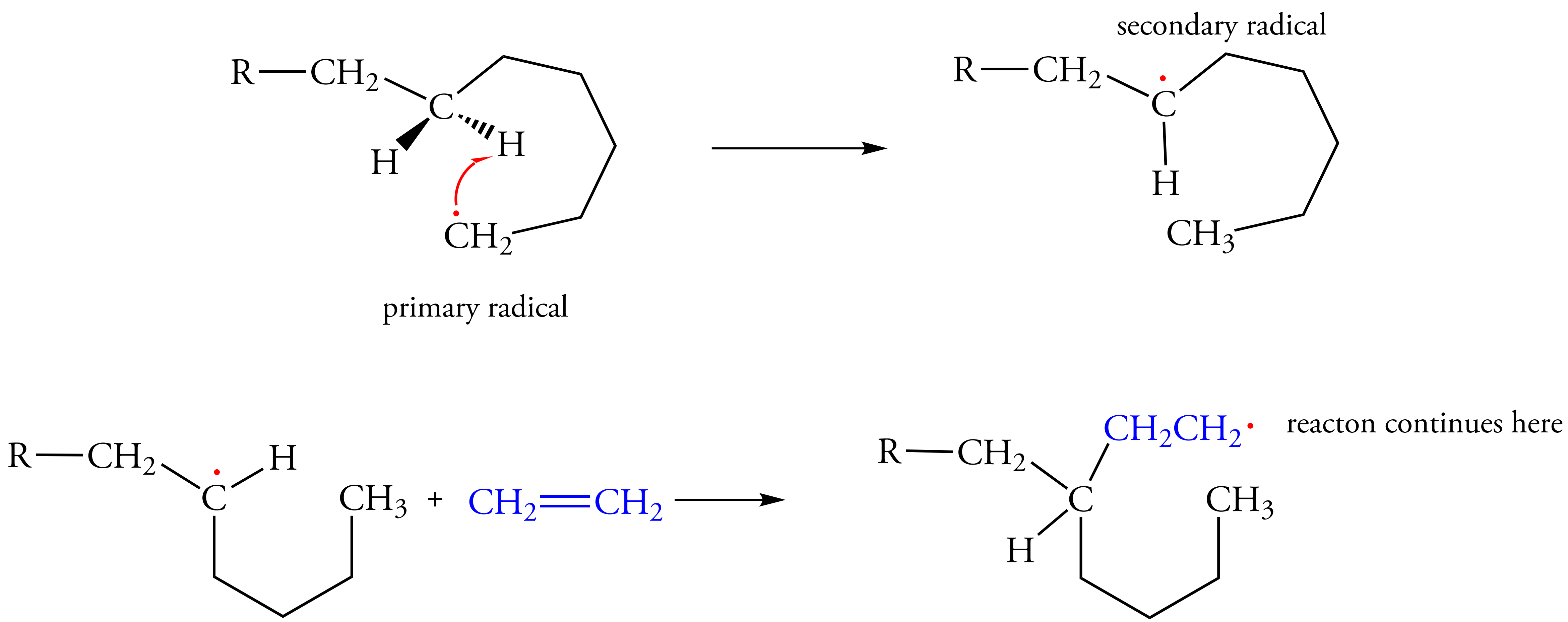
$$R'{-}S\cdot \;+\; CH_2{=}CH_2 \longrightarrow R'{-}S{-}CH_2CH_2\cdot$$

initation of another chain



benzoquinone

28.5 ADDITION POLYMERIZATION
Chain Branching



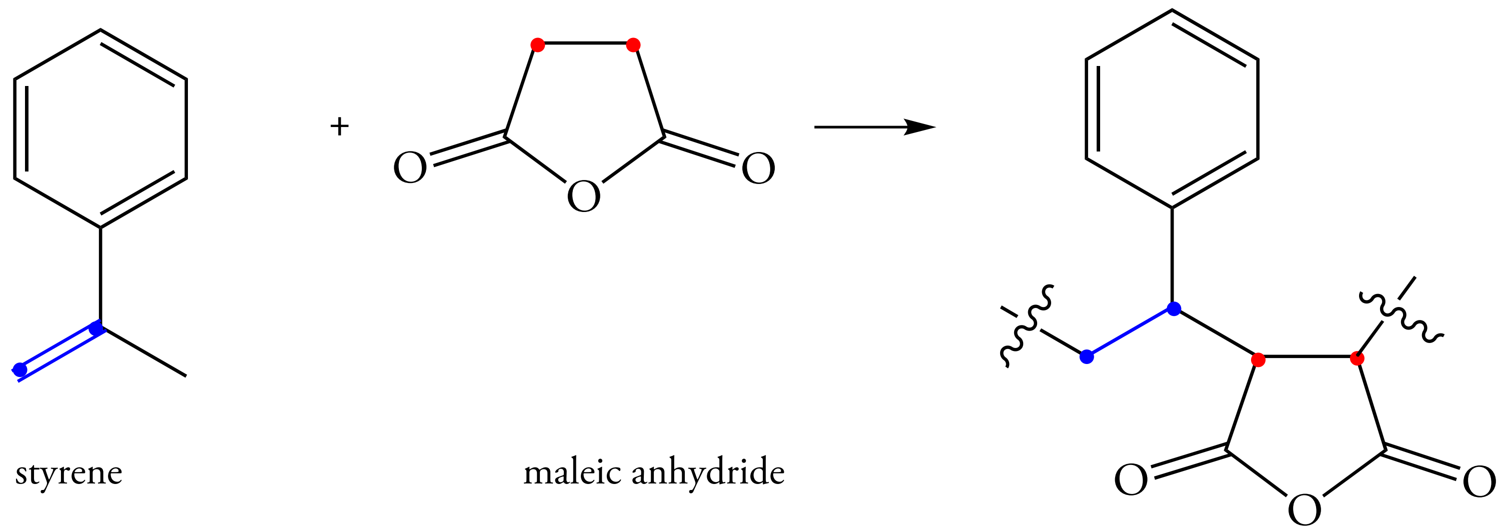
28.6 COPOLYMERIZATION OF ALKENES

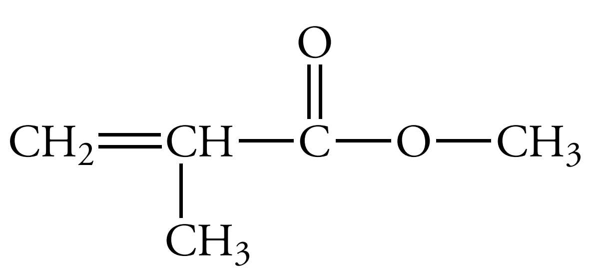
n A + n B ⟶ —A—A—A—A—A— + —B—B—B—B—B—

n A + n B ⟶ —A—B—A—B—A—B—A—B—A—B—

an alternating copolymer

n A + n B ⟶ —A—A—B—A—A—B—A—A—A—B—A—





methyl-2-methylpropenoate

28.7 CROSS-LINKED POLYMERS

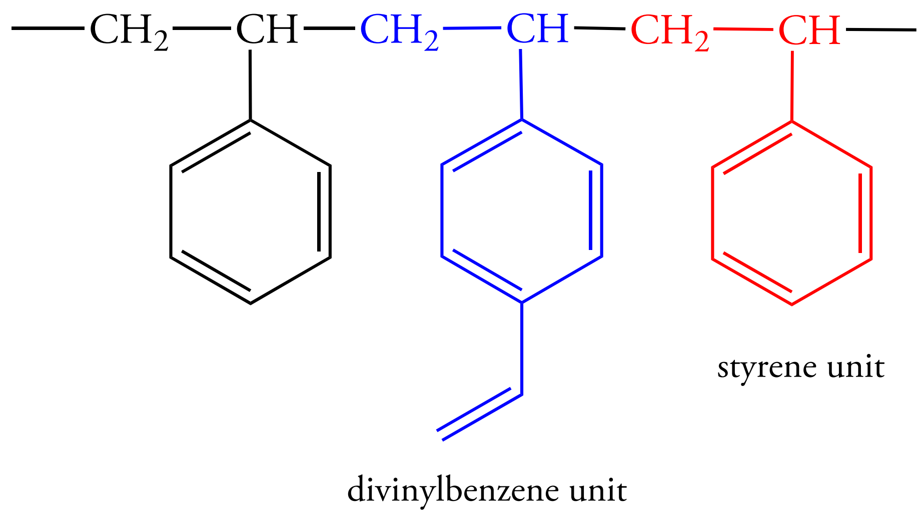
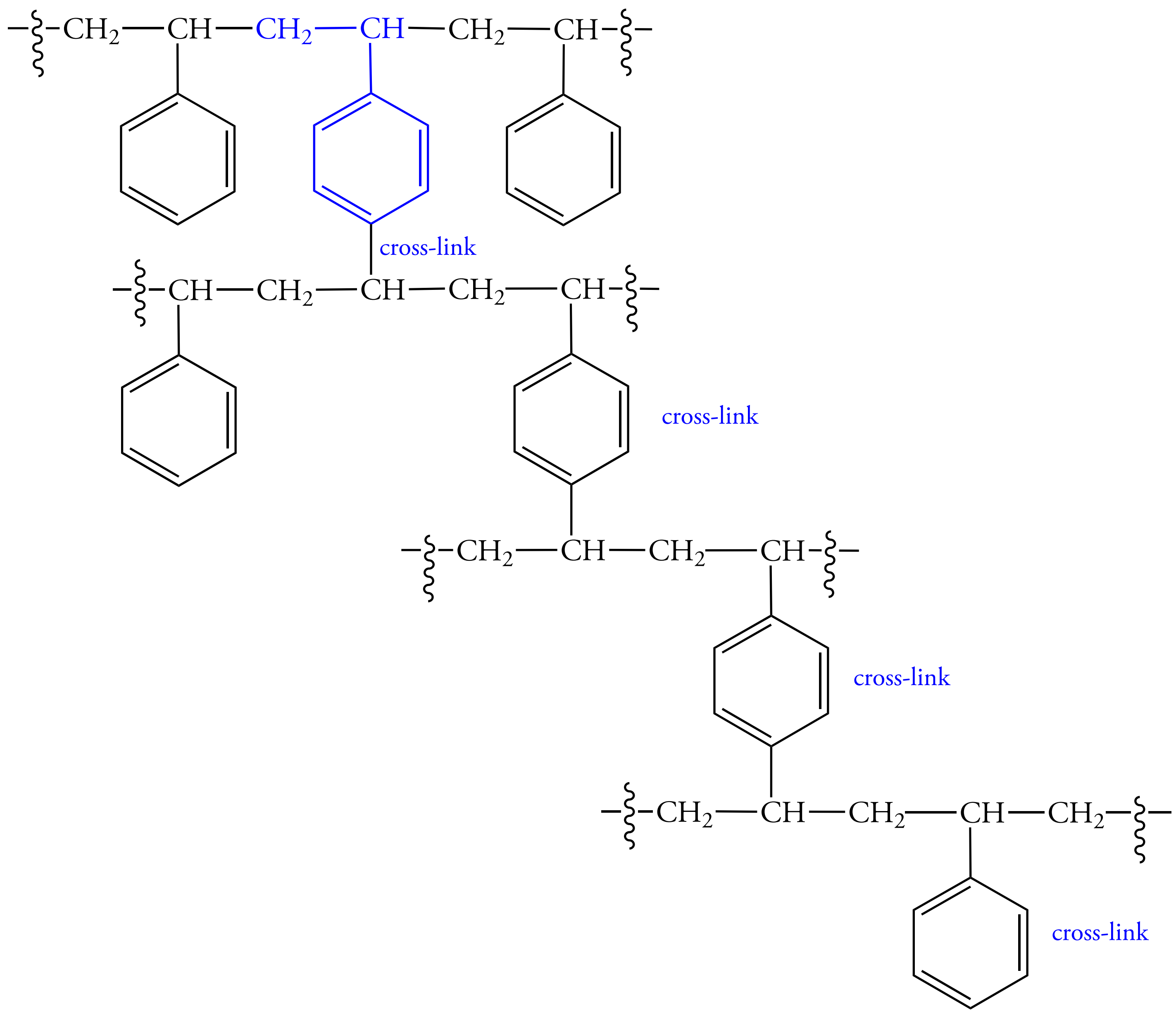
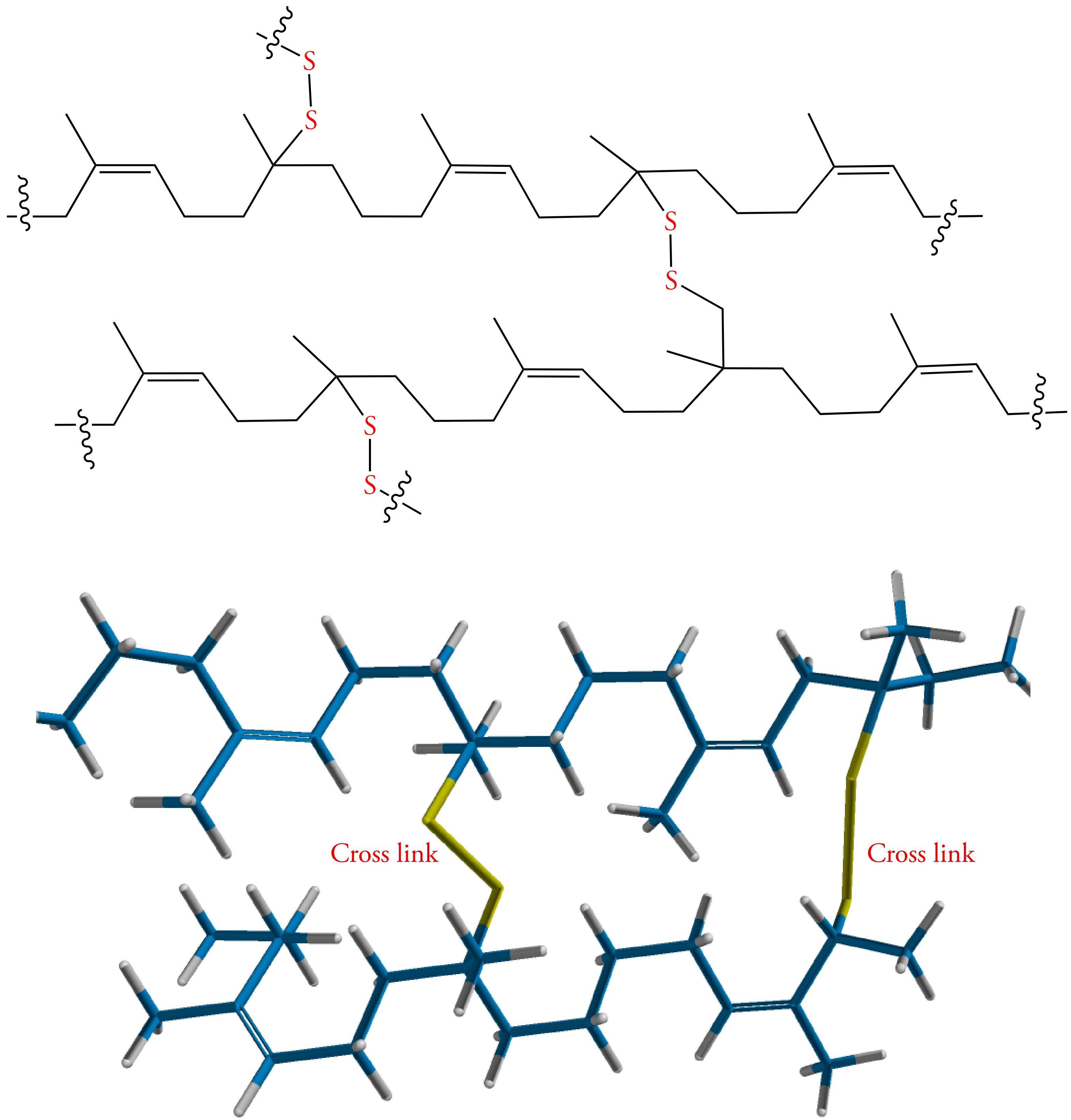


Figure 28.8 Cross-Links in Addition Polymerization

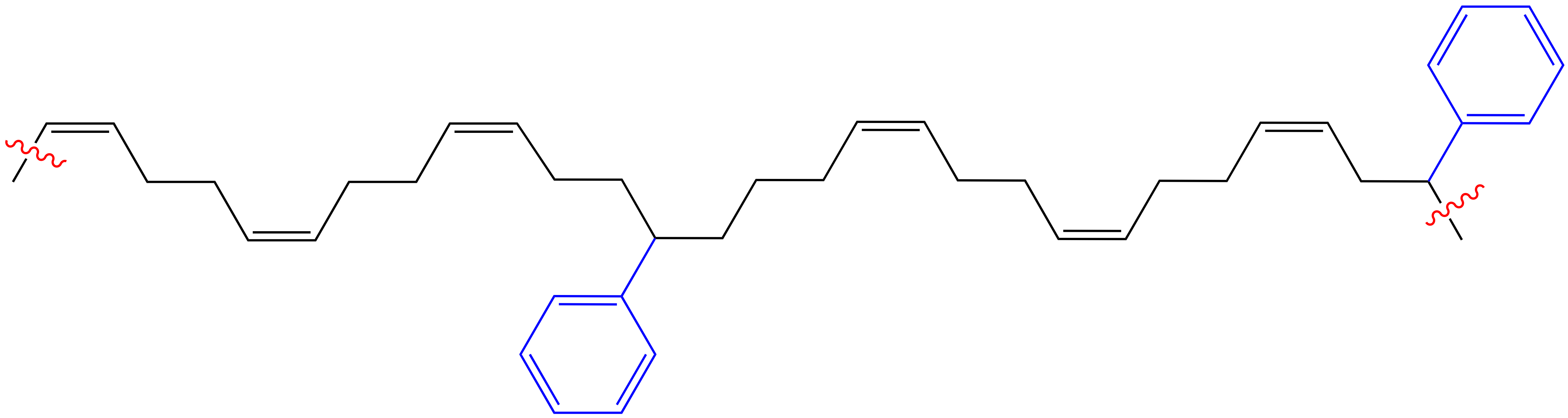


28.7 CROSS-LINKED POLYMERS

Figure 28.9 Cross-Links in Vulcanized Polyisoprene



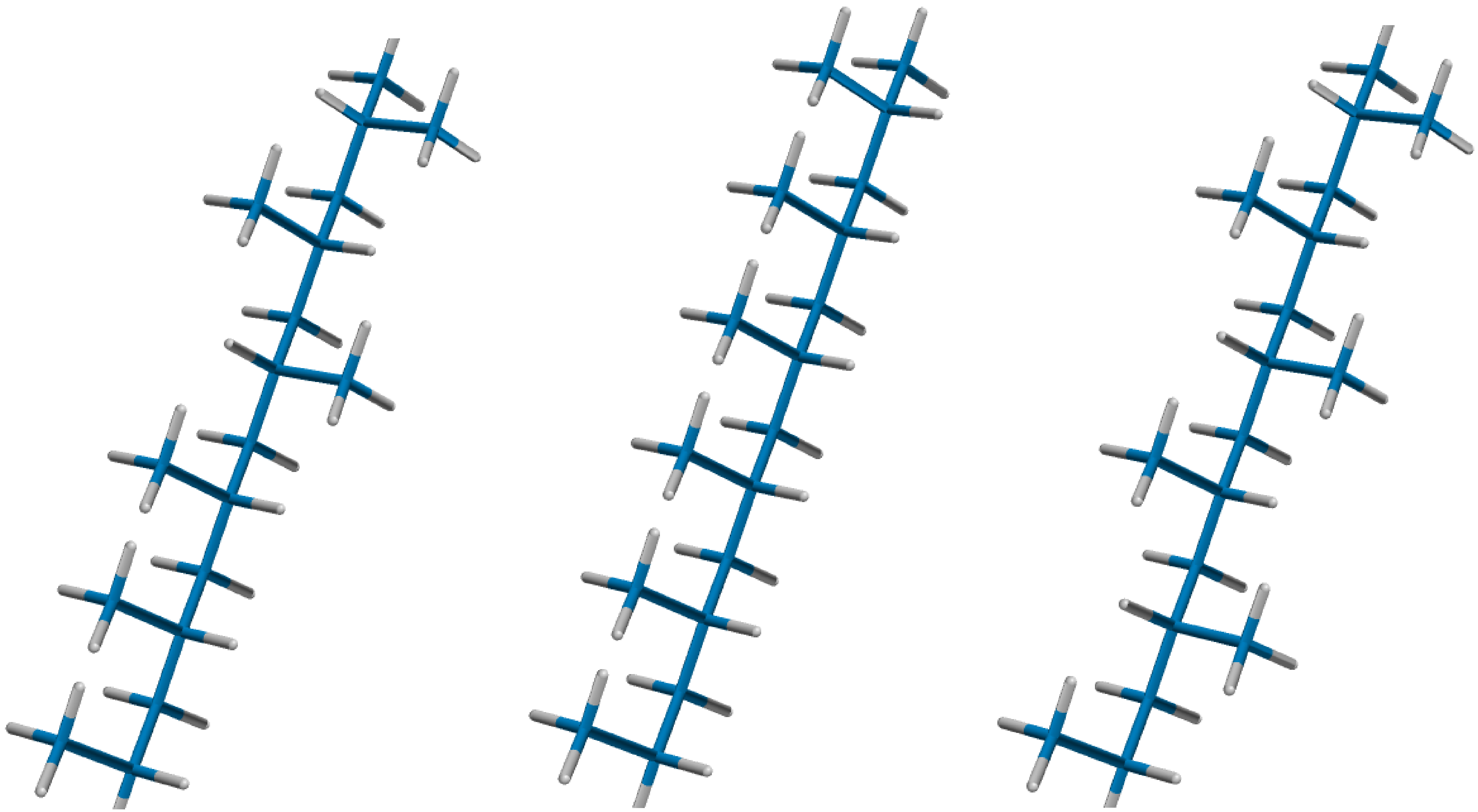
Copolymers in Automobiles



representation of an SB polymer (1:3) ratio

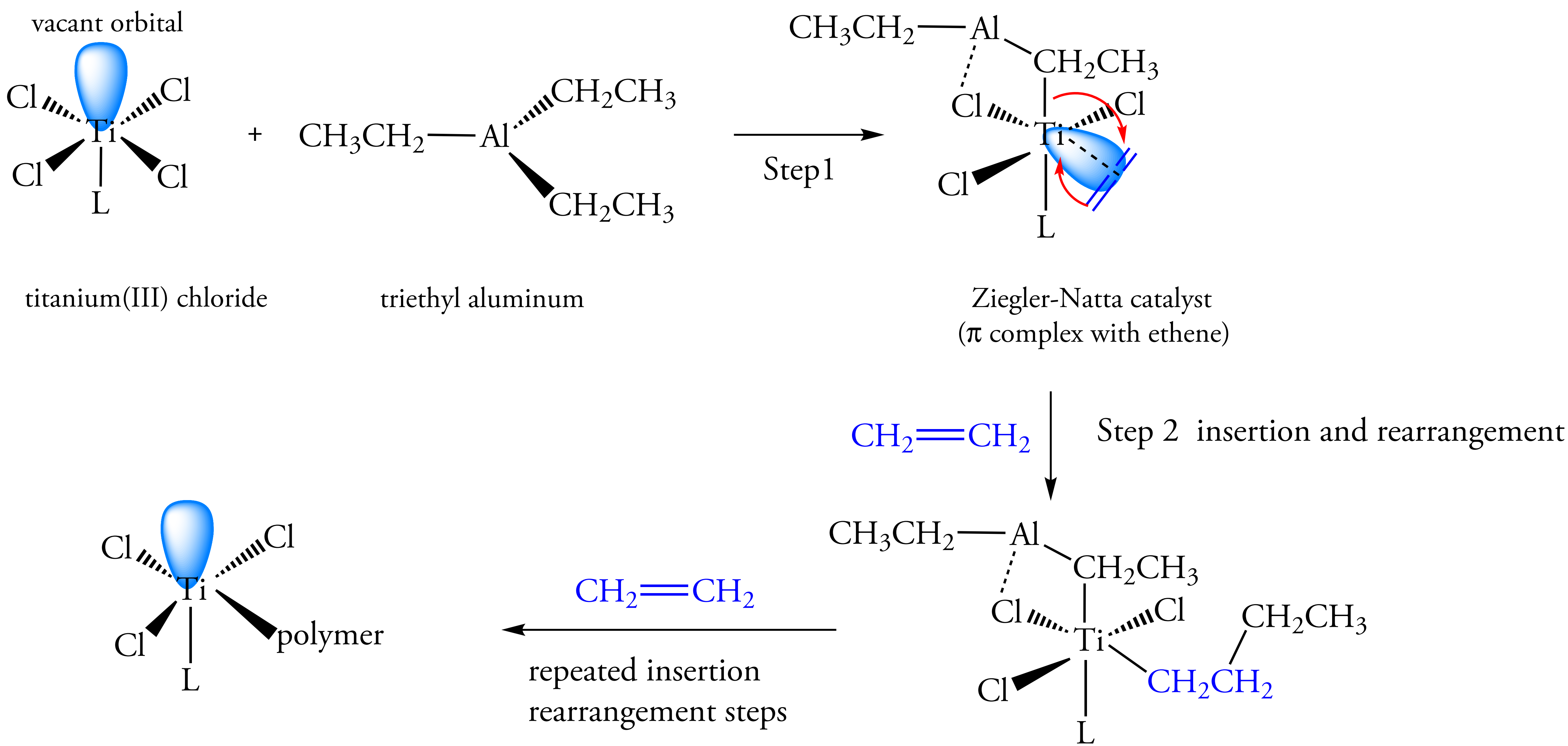
28.8 STEREOCHEMISTRY OF ADDITION POLYMERIZATION

Figure 28.10 Atactic, Syntactic and Syndiotactic Polymers



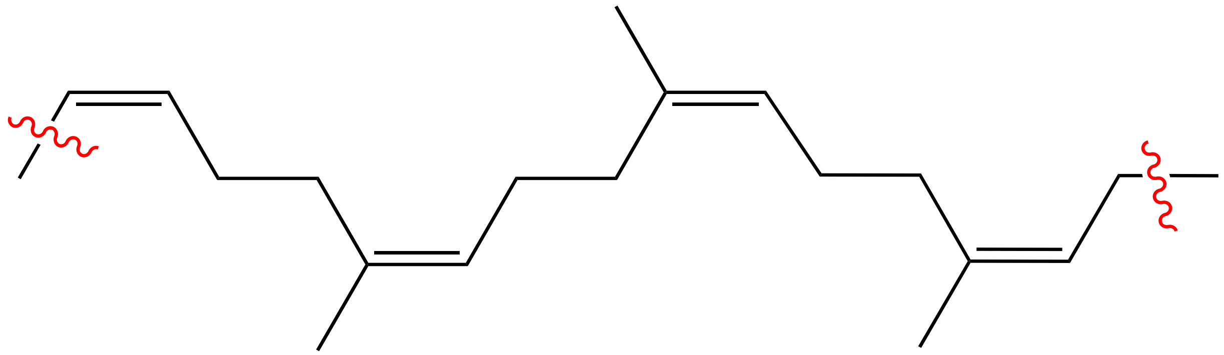
Atactic Isotactic Syndiotactic

Figure 28.11 Schematic Diagram of Steps in Ziegler-Natta Catalysis

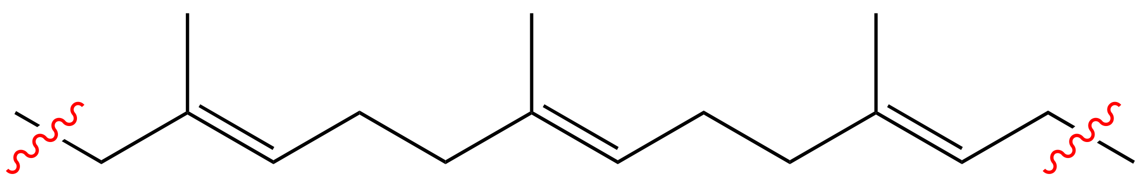


28.8 STEREOCHEMISTRY OF ADDITION POLYMERIZATION

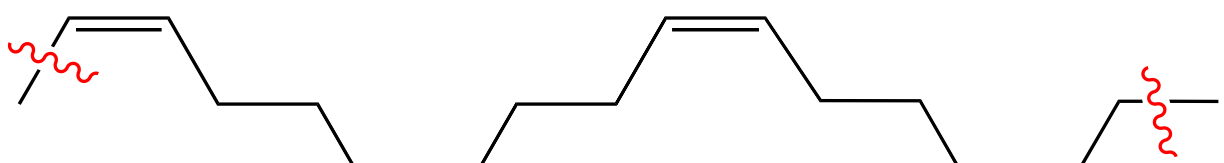
Diene Polymers



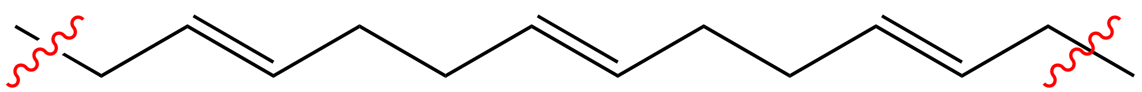
natural rubber (polyisoprene, all *cis*)



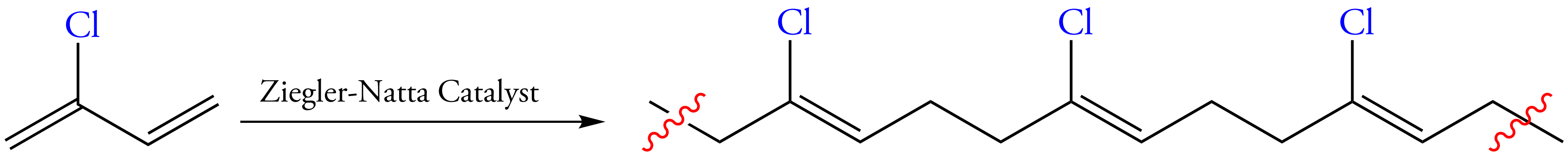
gutta-percha (all *trans*)



cis-poly(1,3-butadiene)



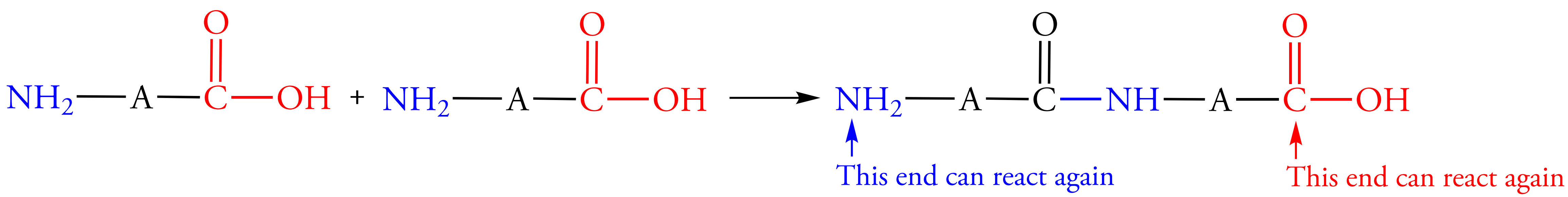
trans-poly(1,3-butadiene)

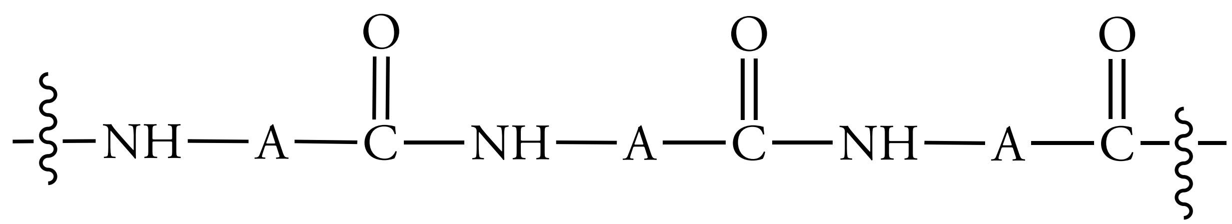


Neoprene

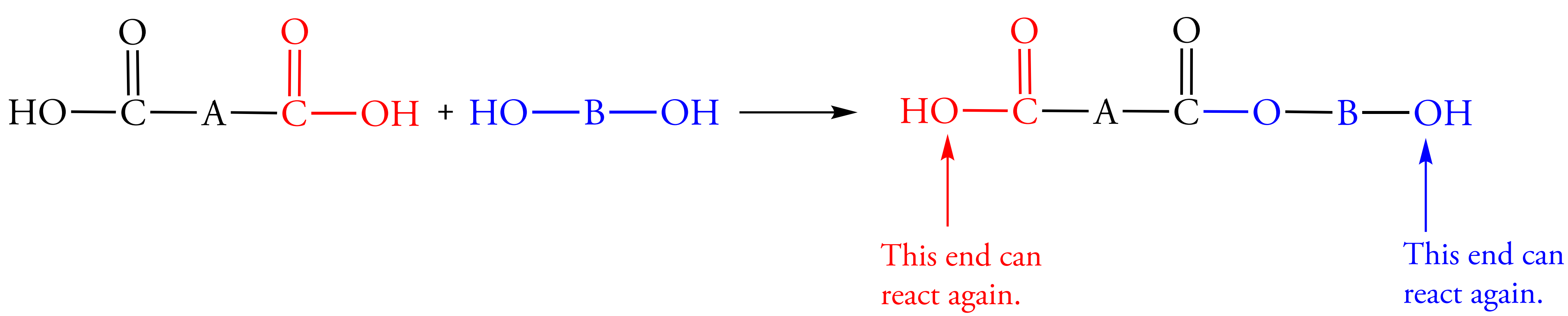
28.9 CONDENSATION POLYMERS

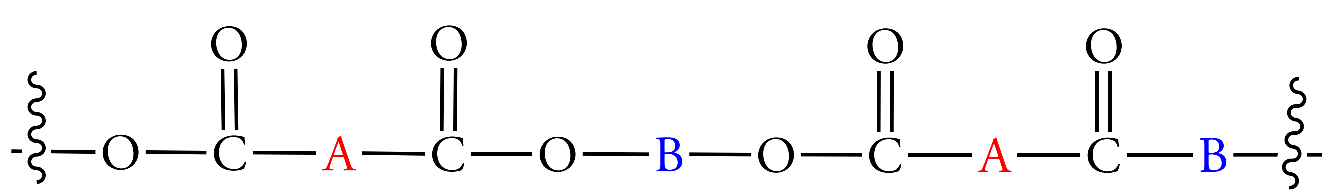
Types of Monomers





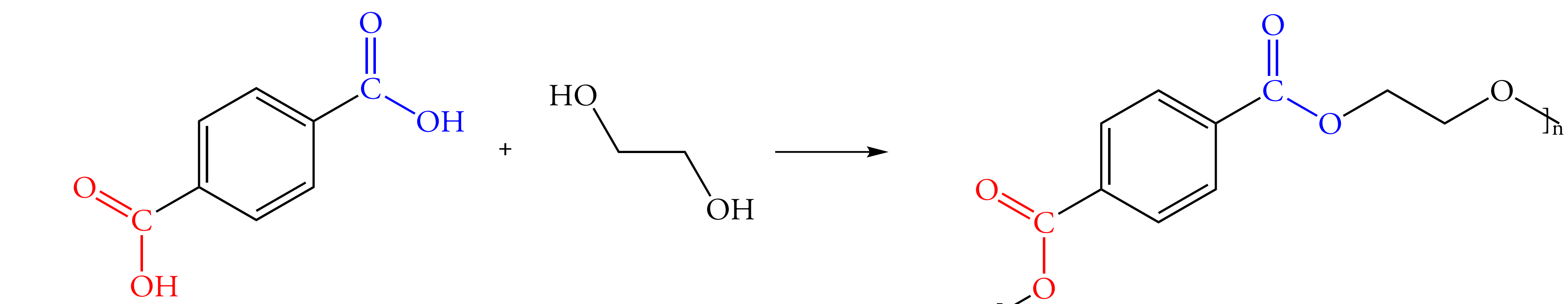
(homopolymer of an amino acid)



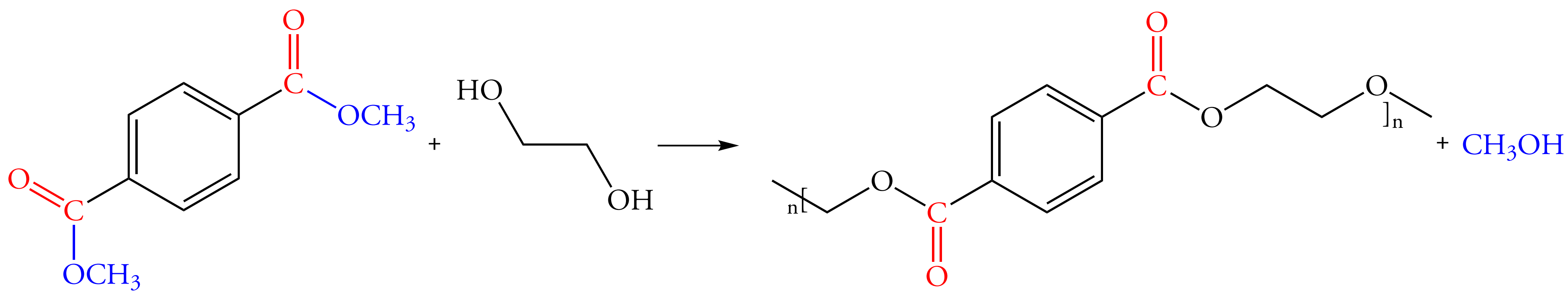


(an alternating copolymer)

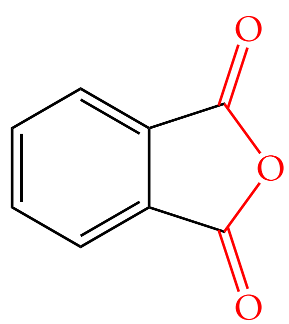
28.10 POLYESTERS



terephthalic acid · ethylene glycol · PET



dimethyl terephthalate · ethylene glycol · Dacron



phthalic anhydride

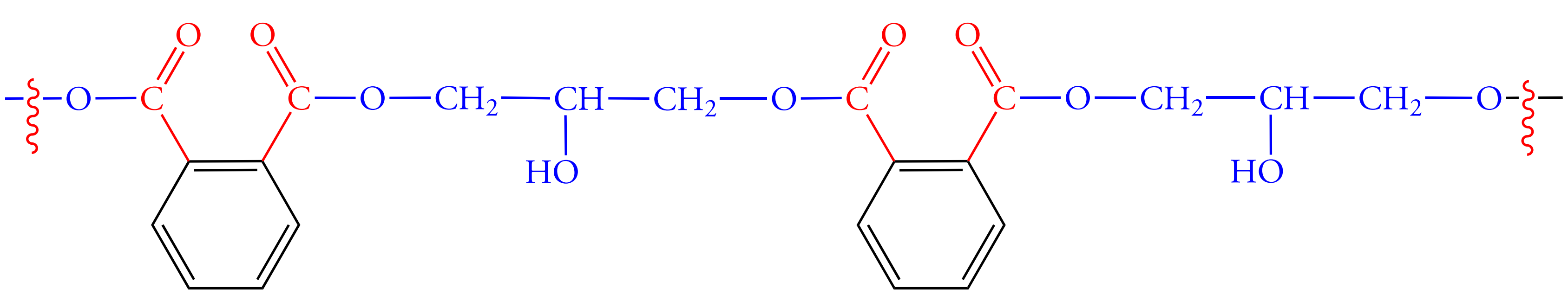
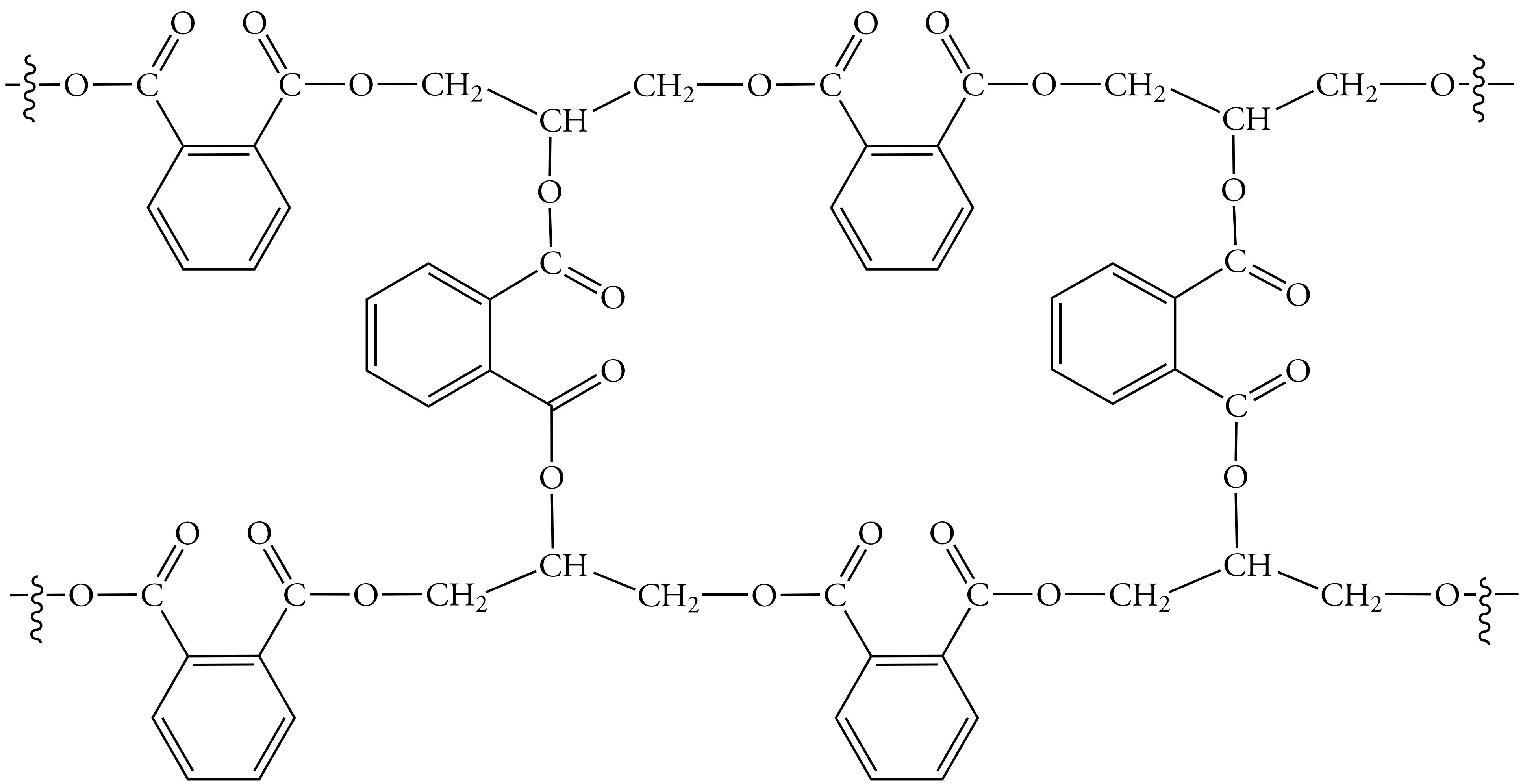
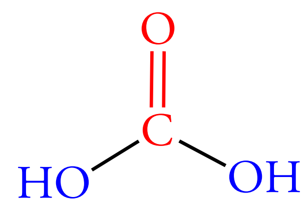


Figure 28.12 Cross-Links in a Condensation Polymer

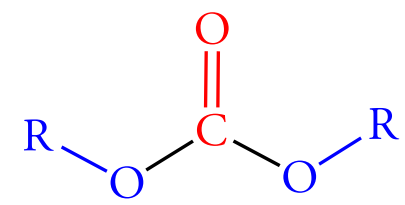
The reaction of 2 moles of 1.2,3-propanetriol and 3 moles of phthalic anhydride gives a cross-linked polymer called a glyptal.



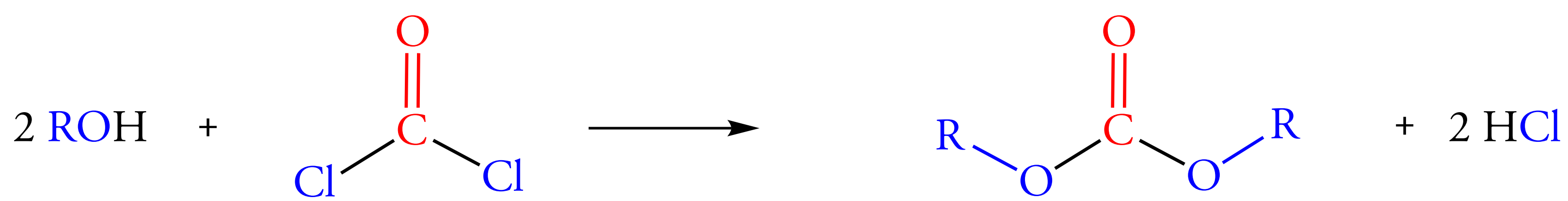
28.11 POLYCARBONATES



carbonic acid

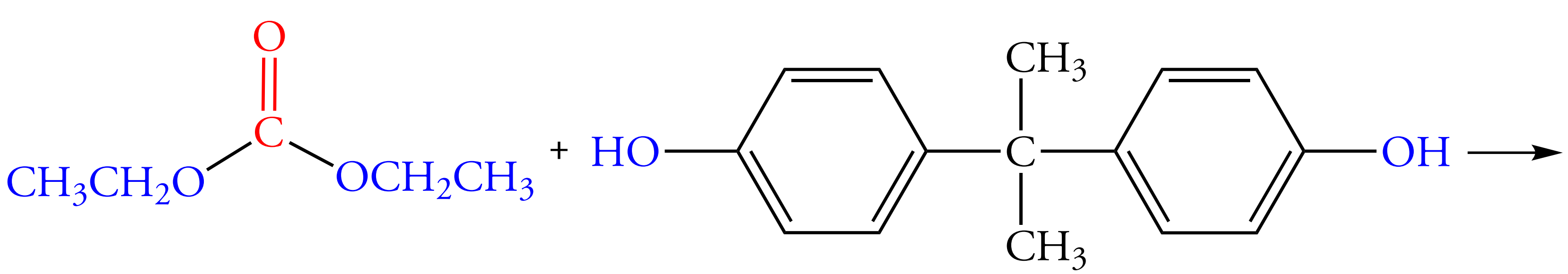


(a dialkyl carbonate)

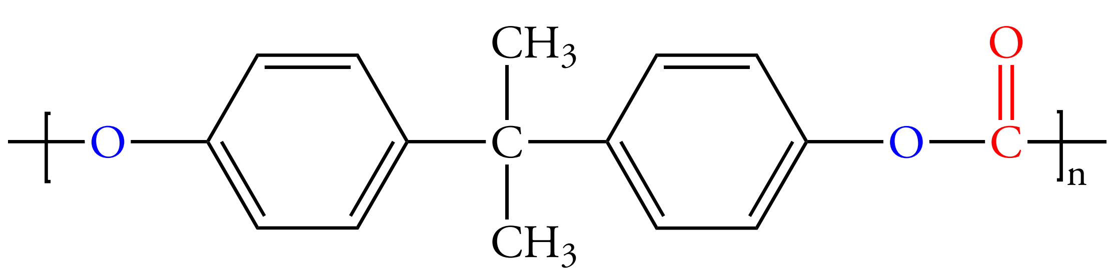


phosgene

(a dialkyl carbonate)

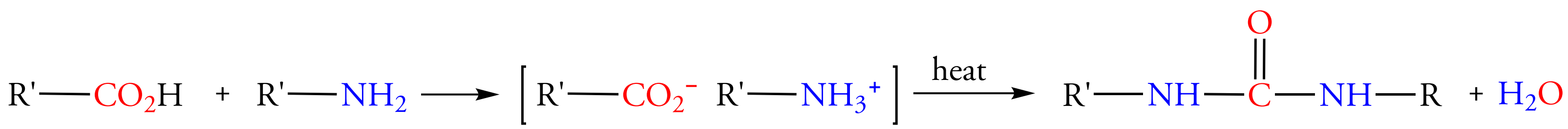


bisphenol A

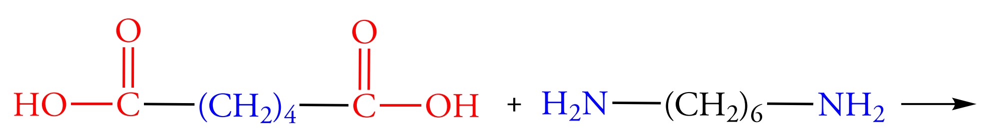


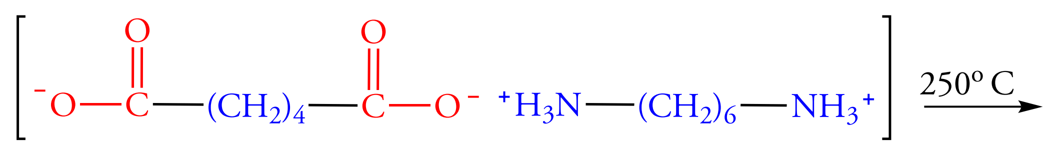
Lexan

28.12 POLYAMIDES

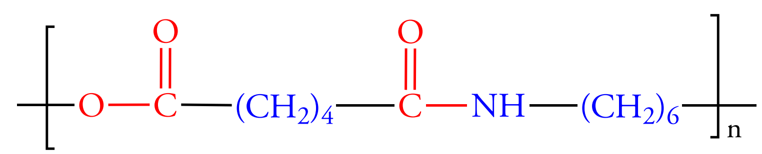


(an ammonium salt
of a carboxylic acid)

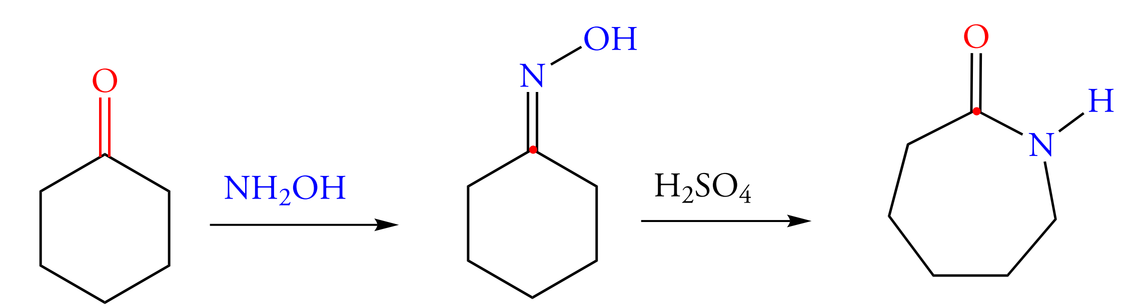




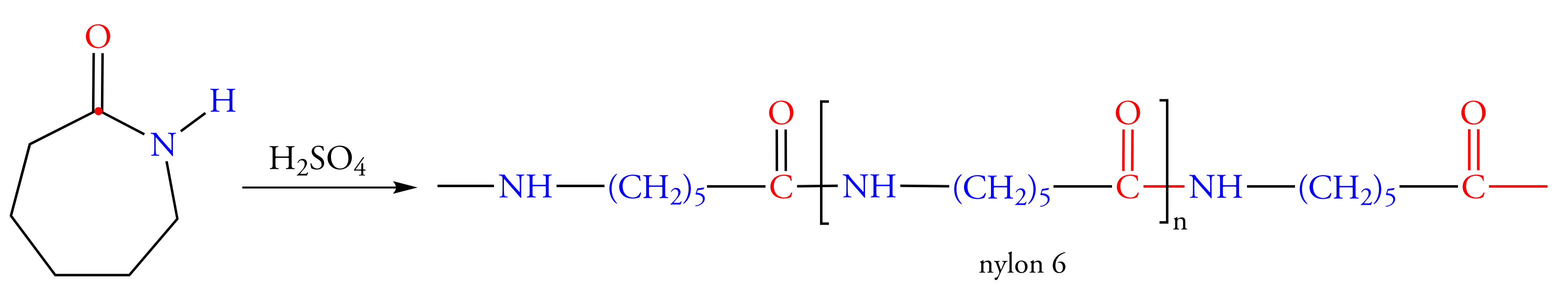
nylon salt



nylon 6,6

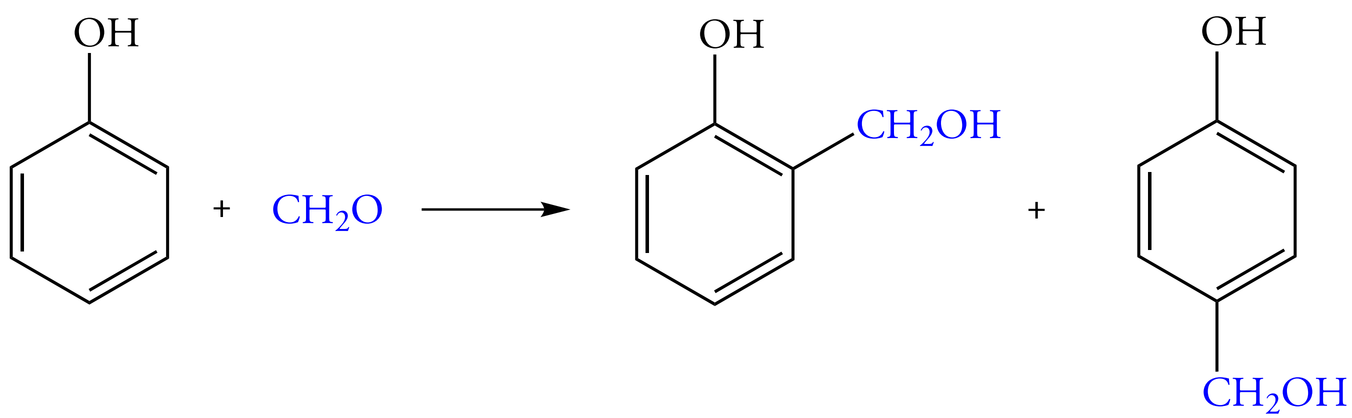


cyclohexanone   cyclohexanone oxime   ε-caprolactam

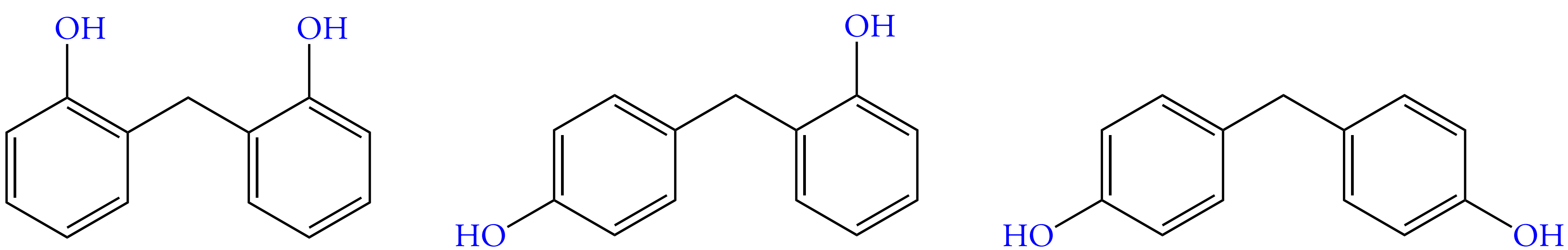


nylon 6

28.13 PHENOL-FORMALDEHYDE POLYMERS



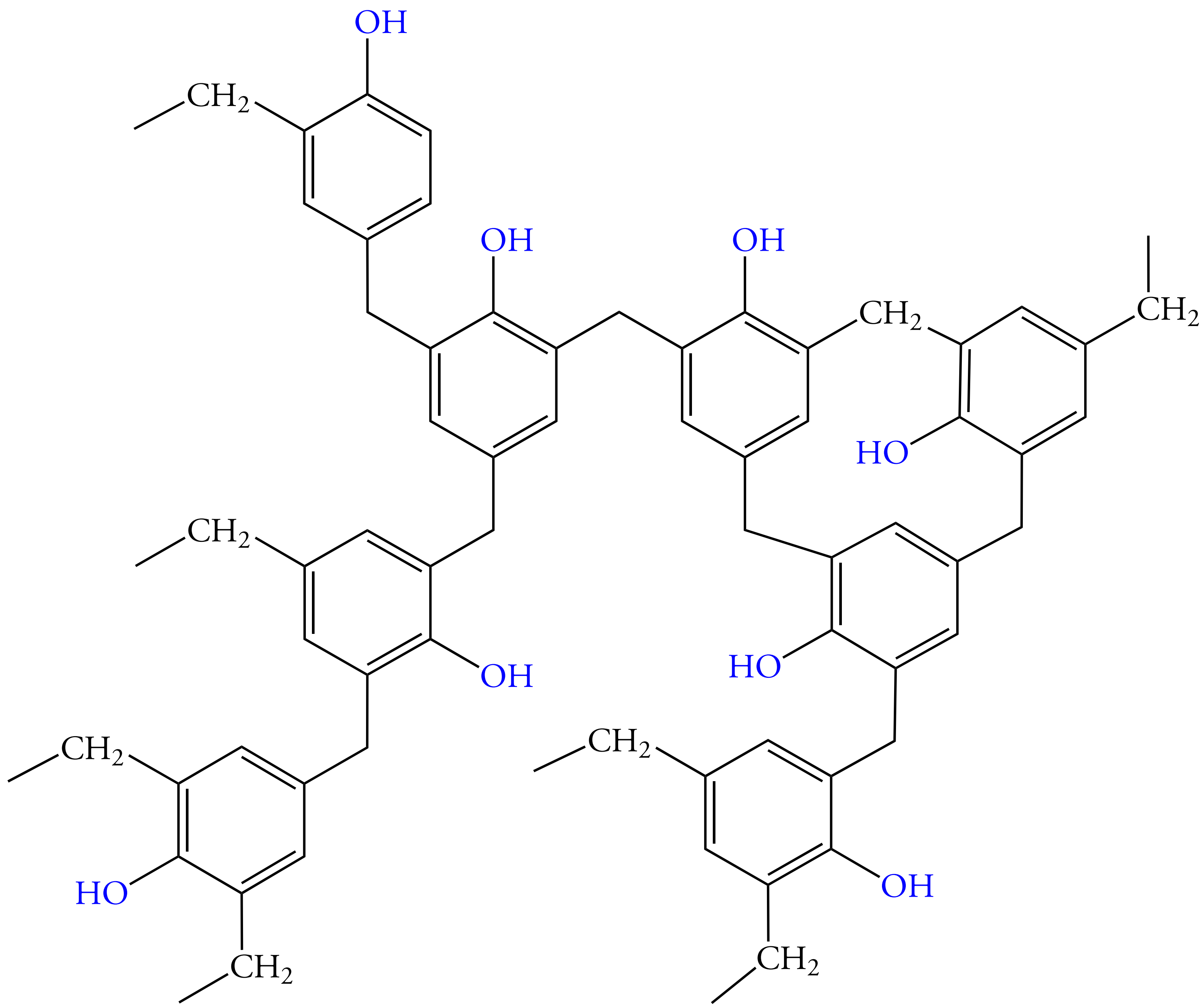
hydroxymethylphenols



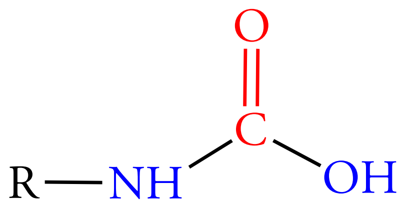
bis(hydroxyphenyl)methanes

28.13 PHENOL-FORMALDEHYDE POLYMERS

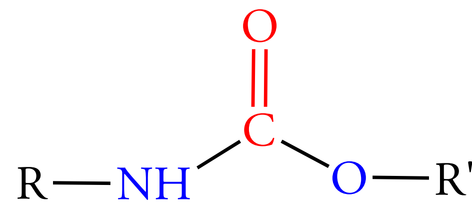
Figure 28.13 Cross-links in Thermosetting Plastic Bakelite



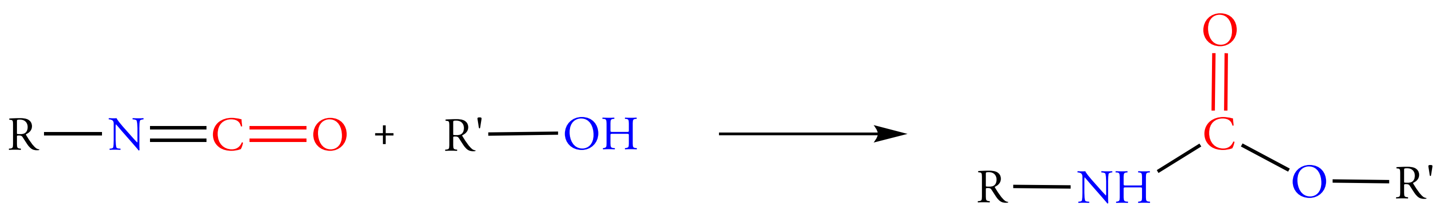
28.14 POLYURETHANES



carbamic acid

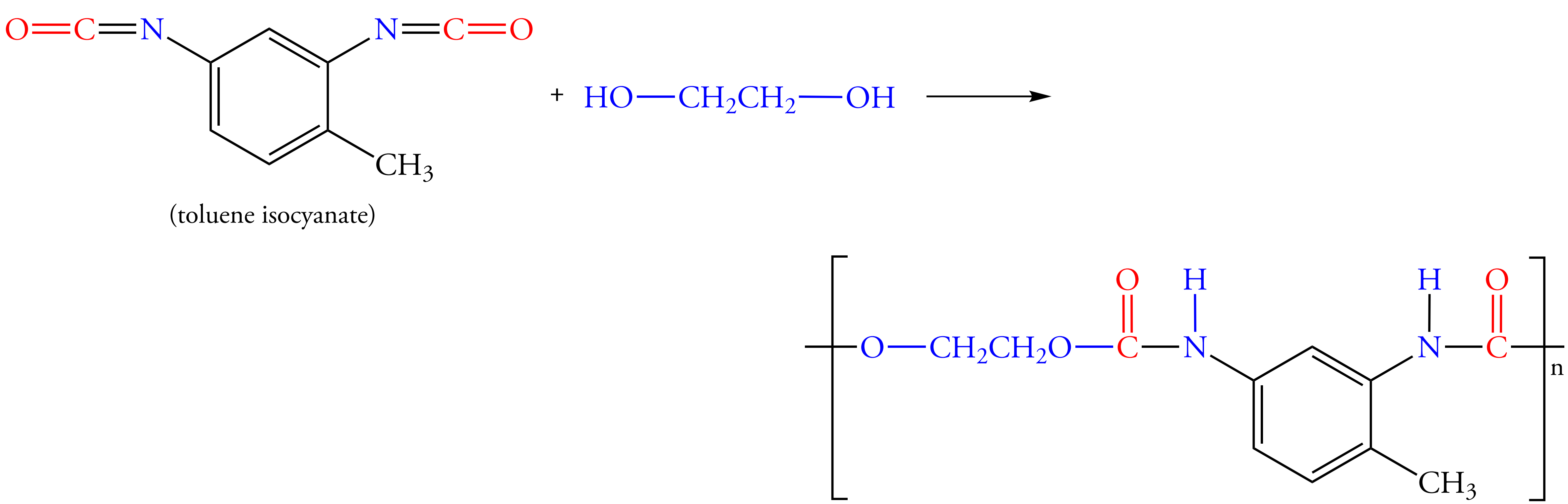


(a urethane)



(an isocyanate)

(a urethane)



(toluene isocyanate)

(a polyurethane)