Polymers

- *Polymers* are large molecules that are formed by linking many smaller molecules called *monomers*.

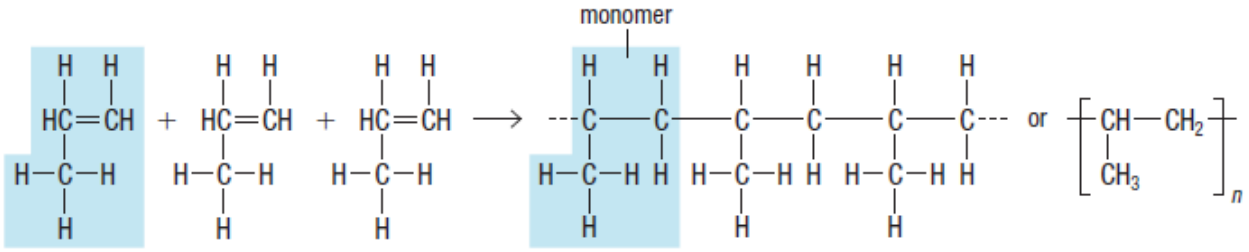


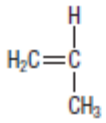
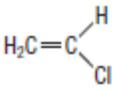
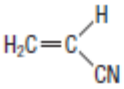
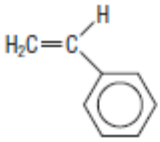
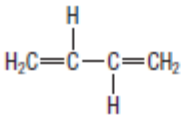
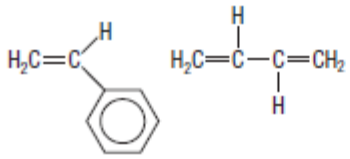
Figure 2 The polymerization of propene produces polypropene. Note how the structures of the reactant molecules are drawn so that their carbon–carbon double bonds are all aligned but the single bonds are above and below.

- *homopolymers* are polymers made up of just one repeating monomer
- *copolymers* are polymers made up of two or more monomers combined
- The monomers and types of linkages can be controlled to produce polymers with specific properties (strength, flexibility etc.)
- There are *natural* polymers such as carbohydrates, proteins, and DNA; and *synthetic* polymers such as plastics.
- Monomers can be identical molecules, or different molecules arranged in a repeating pattern
- *Polymerization* is the process of linking monomers to form a polymer.

Addition Polymers

- Result from the addition reactions of small subunits containing double or triple carbon – carbon bonds
- The small monomers link because the multiple bonds break apart as the molecules join

Table 1 Familiar Addition Polymers

Monomer		Polymer	
Name	**Formula**	**Name**	**Uses**
ethene	$H_2C=CH_2$	polyethene (polyethylene)	plastic bottles and pipes, insulation on electric wires, toys
propene		polypropene (polypropylene)	rope, packaging film, carpet fibres, toys 
chloroethene (vinyl chloride)		polyvinyl chloride (PVC)	pipes, construction materials, floor tile, clothing, reusable bags 
cyanoethene (acrylonitrile)		polyacrylonitrile (PAN)	carpet fibres, synthetic fabrics
tetrafluoroethene	$F_2C=CF_2$	polytetrafluoroethene (Teflon)	non-stick cookware, electrical insulation, ball bearings
vinylbenzene (styrene)		polystyrene	food and beverage containers, insulation, toys 
butane-1,3-diene (butadiene)		polybutadiene	tires, industrial coatings
vinylbenzene (styrene) and butane-1,3-diene (butadiene)		styrene–butadiene rubber (a copolymer)	synthetic rubber

Properties of Addition Polymers

- unreactive because the multiple bonds have been broken and are now more stable single bonds (unsaturated alkenes are transformed into saturated alkanes)
- flexible and malleable because of weak intermolecular forces
- can form crosslinks (strong covalent bonds between two different polymer chains)

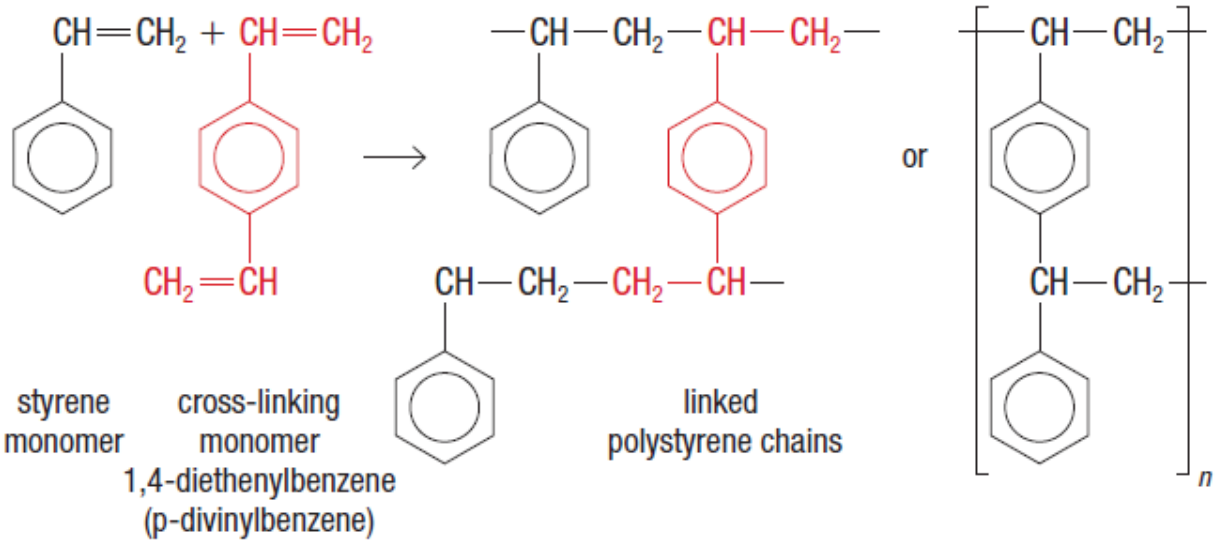
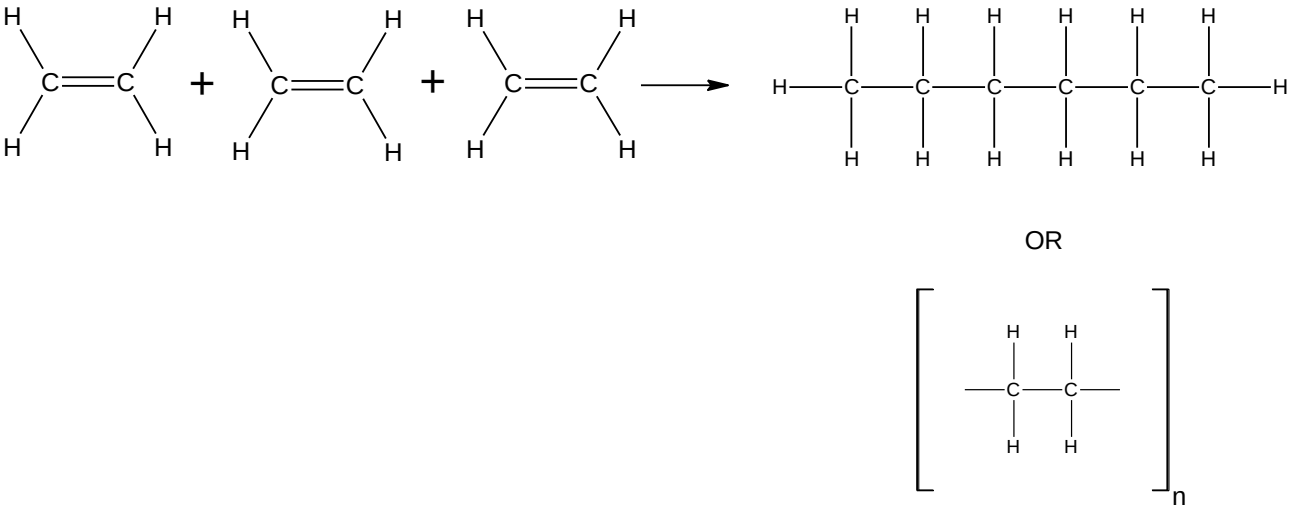


Figure 10 The addition of 1,4-diethylbenzene to polystyrene allows cross-links to form between adjacent polymer chains.

Example

Addition polymerization of ethene to form polyethene (aka polyethylene):



Condensation Polymers

- monomers are linked together by formation of ester or amide bonds
- water is usually produced in this reaction
- each monomer must have two functional groups – one at each end of the molecule
- condensation polymers containing amide bonds are called *nylons*, while those containing ester bonds are called *polyesters*

Example:

hexane – 1, 6 - diamine + hexanedioic acid