



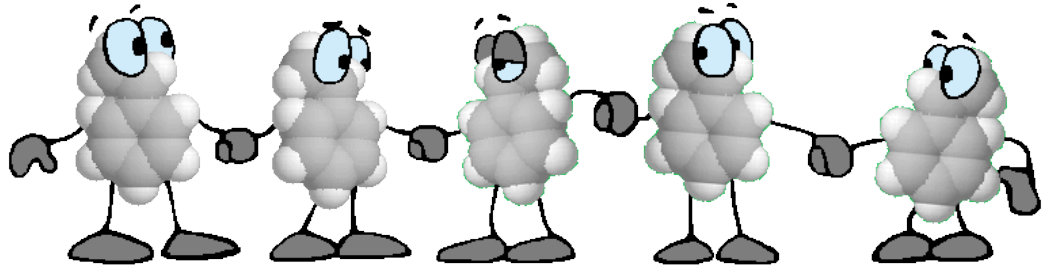
POLYMERS



'Approximately 80% of the organic chemical industry is devoted to the production of synthetic polymers.'

WHAT IS A POLYMER?

- ▶ Polymers are large molecules made up small repeating units called **monomers**



- ▶ Monomers are linked together in a polymerization reaction

Homopolymer: polymer involving a single type of monomer

Copolymer: polymer made up of 2 or more different types of monomers

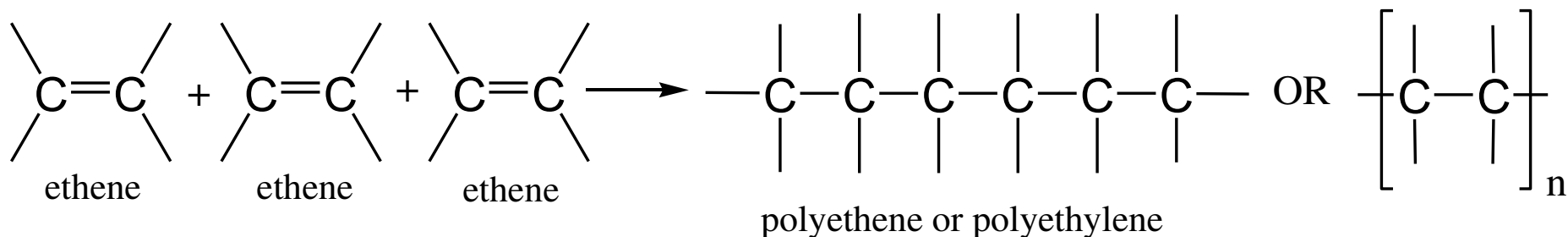
- ▶ Polymers are widely abundant and may be natural or synthetic

(Examples include: rubber, nylon, polyvinyl chloride (PVC), polyethylene, Teflon, Kevlar, carbohydrates, proteins, DNA)

ADDITION POLYMERS

- Addition polymers result from **addition reactions** of monomers containing carbon-carbon double bonds
 - **All atoms in the monomer are kept in the polymer**
- Some examples include: *polyethene, polypropene, polyvinyl chloride, polystyrene and Teflon*

Example



SUBSTITUTED GROUPS AND POLYMERS

- The **reactivity**, **solubility** and **strength** of a polymer is due to the groups that are attached to the polymer chain
 - Chloro, methyl, cyano, phenyl, etc.
- Teflon (polytetrafluoroethane) for example is very unreactive because the C-F is very strong

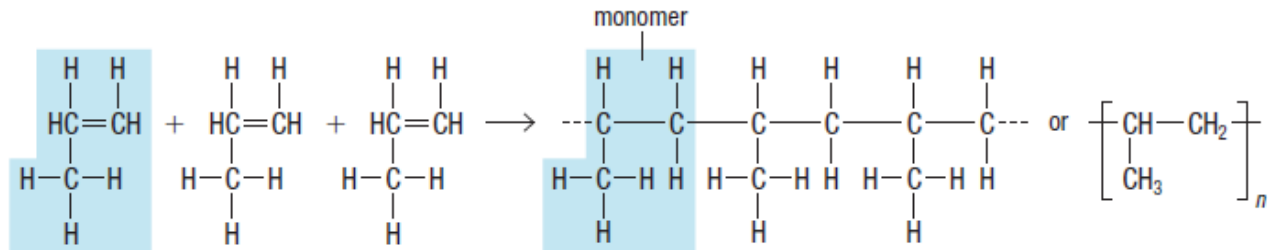


TETRAFLUOROETHYLENE MONOMER

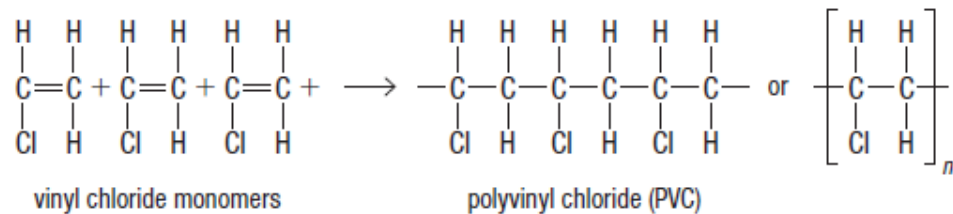
TEFLON POLYMER

SUBSTITUTED GROUPS AND POLYMERS

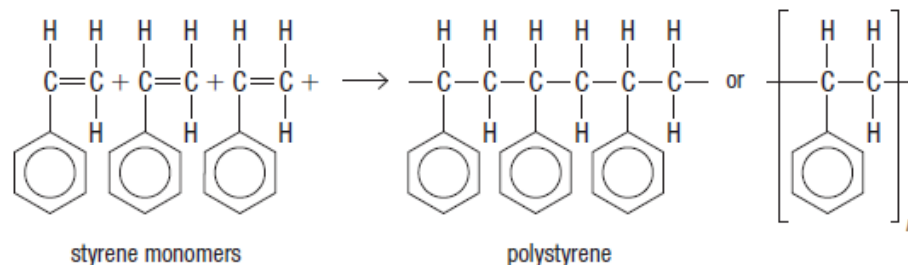
- Polypropene (Polypropylene)



- Polyvinyl chloride (PVC)



- Polyvinyl benzene (Polystyrene)



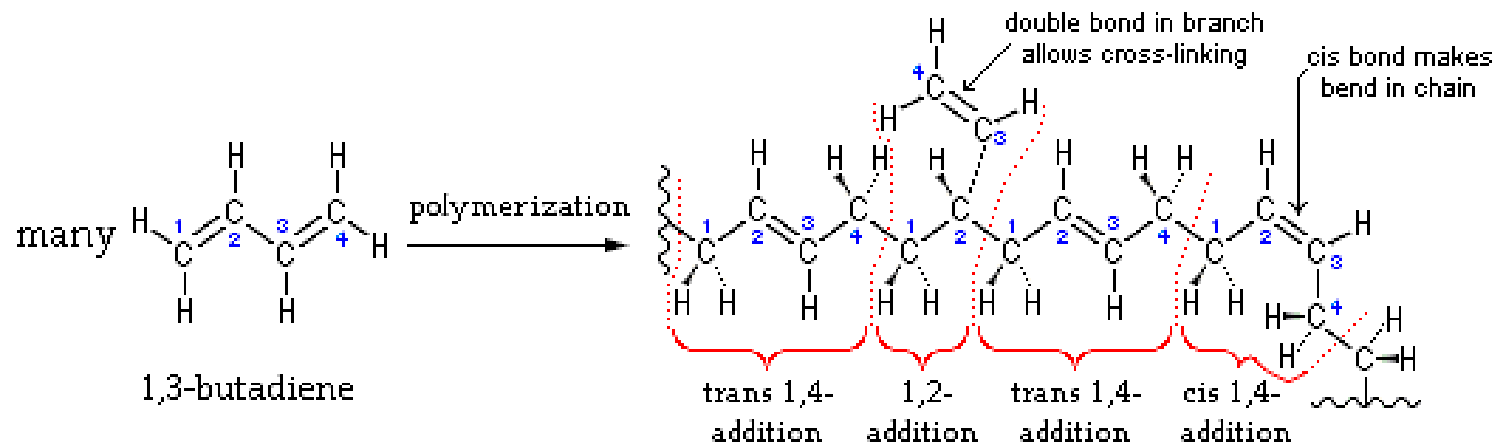
PLASTICS – SPECIAL ADDITION POLYMERS

- **Plastic**: synthetic substance that can be **moulded**, generally under heat and pressure, that *retains its given shape*
- **Chemically unreactive** - stable single bonds
- Flexible and mouldable solids or viscous liquids - van der Waals forces of attraction that exist within them
- Soft & flexible when heated as heat increases molecular motion and allows chains to slide past one another
- Cause major environmental issues
 - <http://www.youtube.com/watch?v=GLgh9h2ePYw>



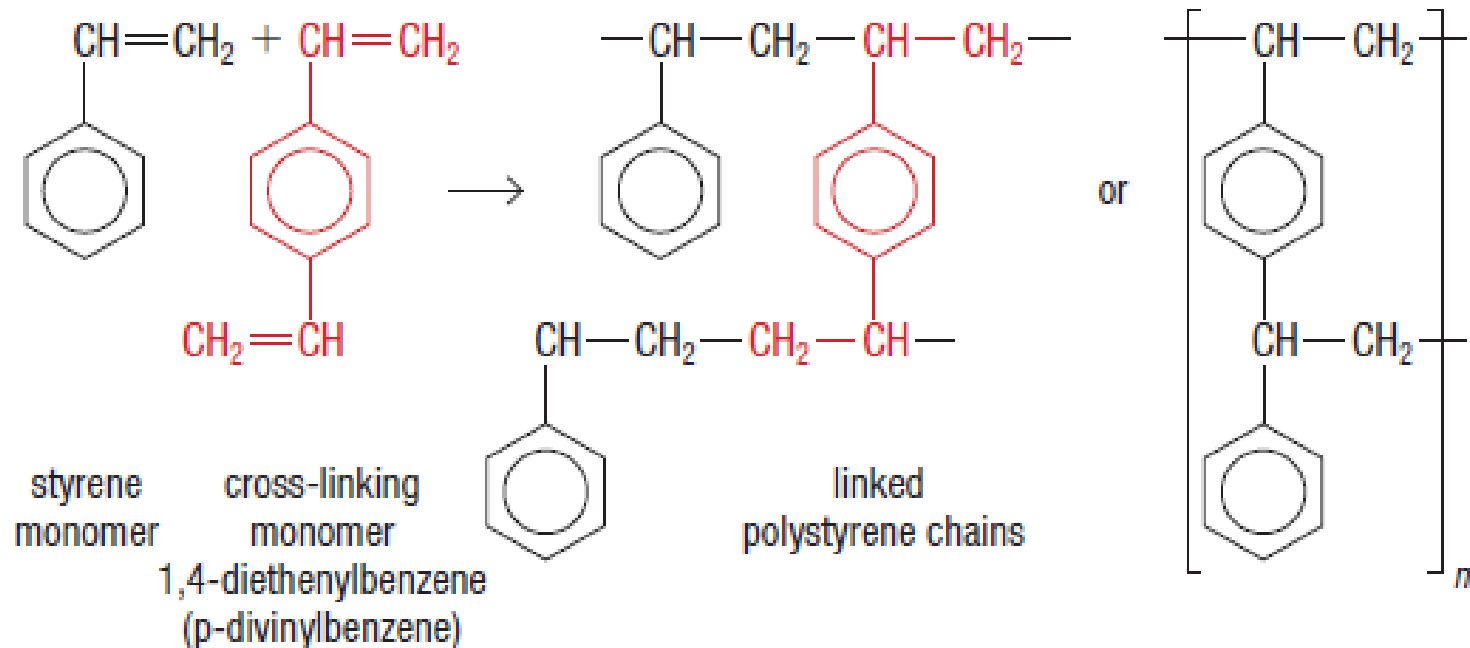
CROSS-LINKING = STRENGTH

- Monomers that contain 2 double bonds (dienes) are able to add to other molecules in two ways
 - A single monomer can be incorporated into 2 different polymer chains causing bridges between the polymer chains
- Bridges are called **crosslinks** and may be formed intermittently along the polymer chains.
- These links between polymer chains are covalent bonds and are much stronger than the van Der Waals forces that would otherwise hold the chains together



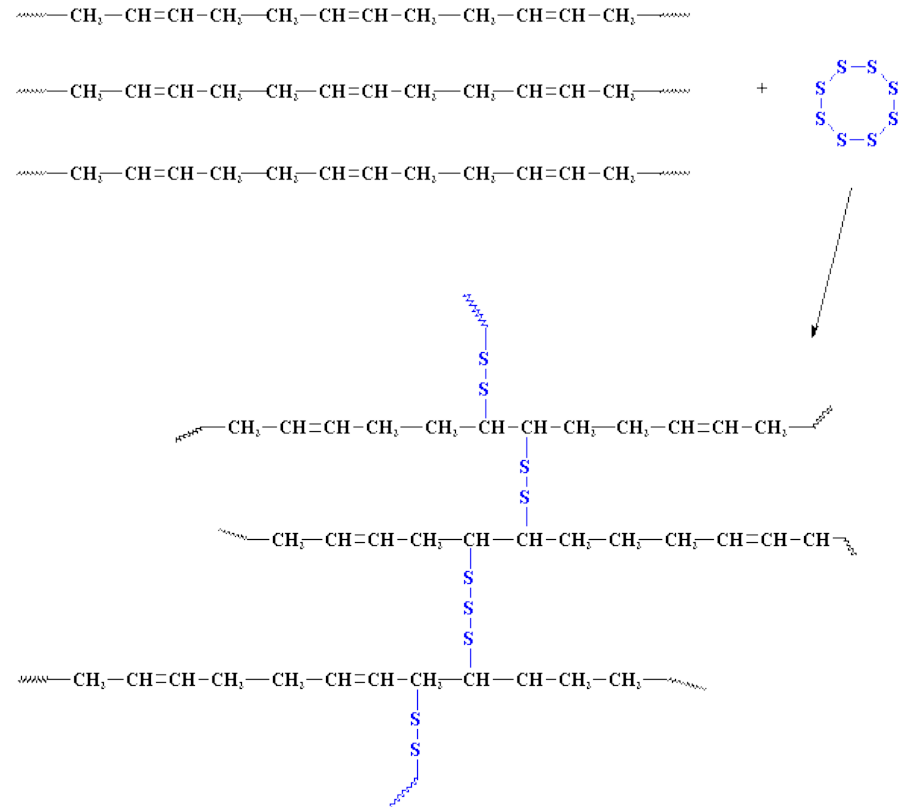
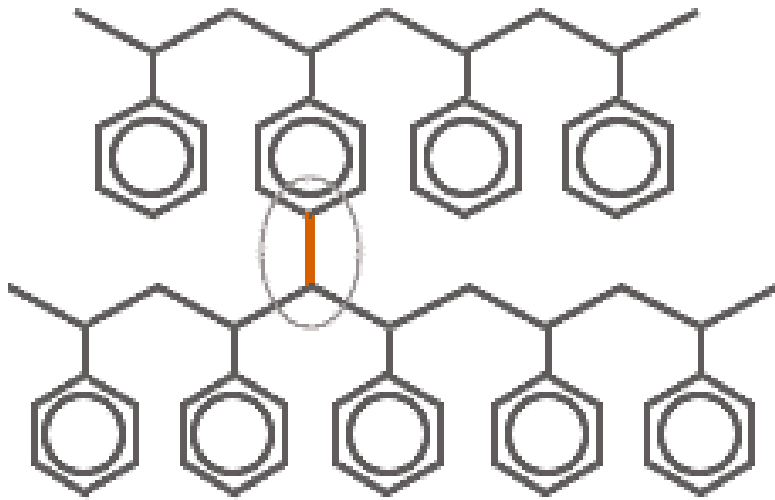
CROSS-LINKING = STRENGTH

1,4-diethylbenzene + polystyrene



CROSS-LINKING = STRENGTH

- As the degree of crosslinking increases so does the strength of the molecule.
- A high degree of crosslinking will also make the polymers **heat resistant** and **more elastic**.
- Crosslinks may also be formed with inorganic crosslinking agents such as sulfur.



CROSS-LINKING = STRENGTH

Disulfide Bridges (Vulcanization)

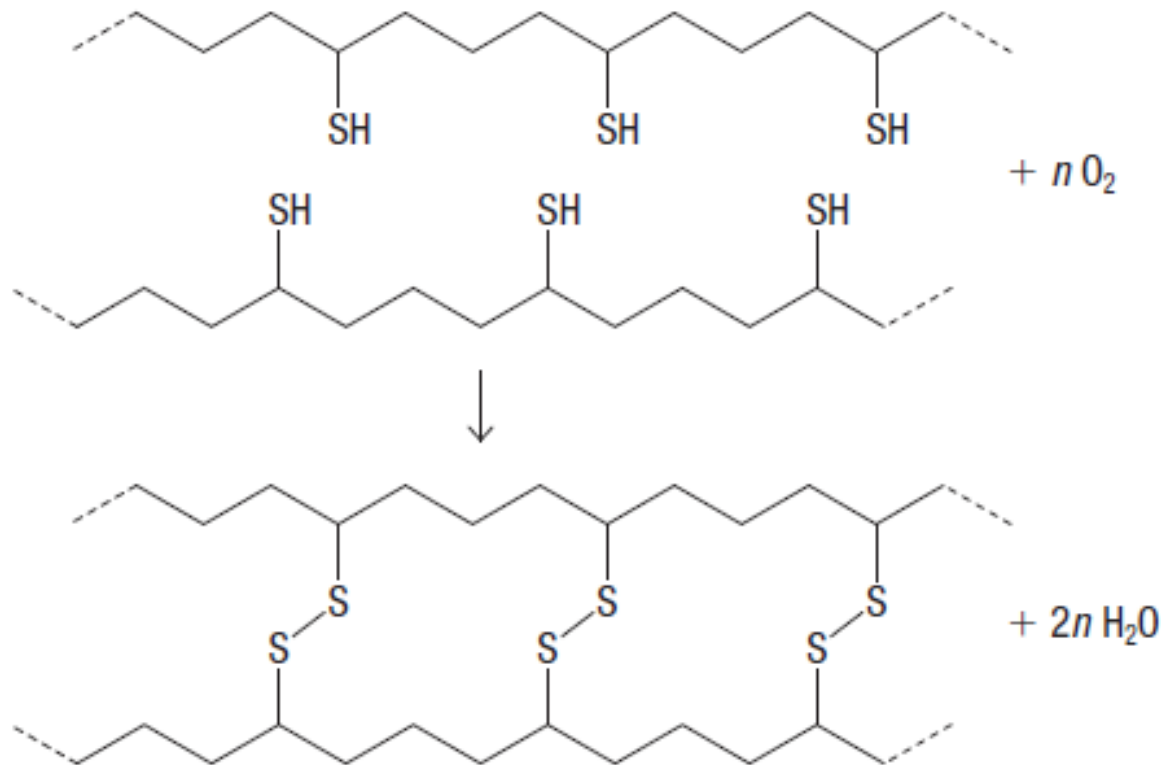
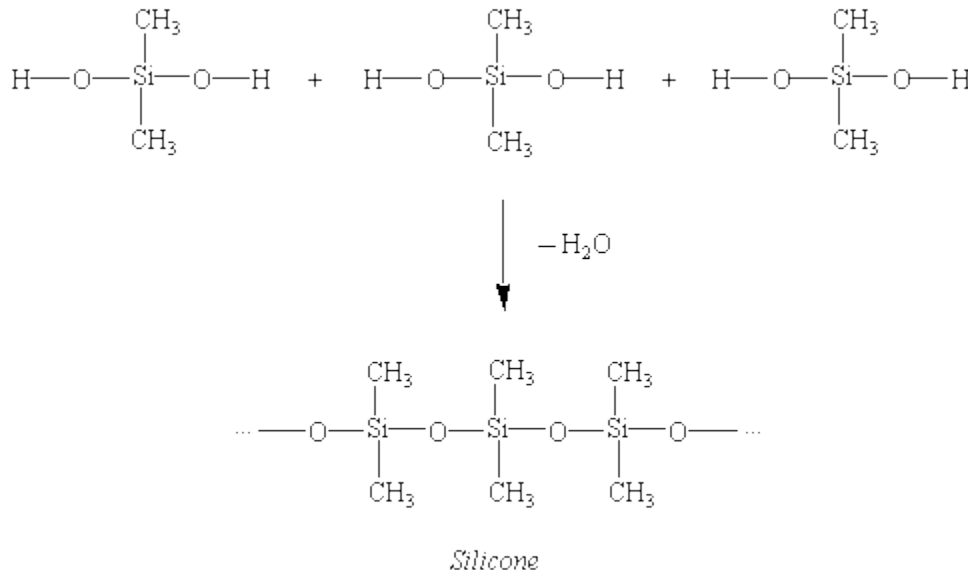


Figure 9 Two polymers with —SH groups can form sulfur–sulfur cross-links.

CONDENSATION POLYMERS

- ▶ Condensation polymers are formed when monomers are linked together through condensation reactions (removal of water)
- ▶ Examples: polyester, nylon, proteins, carbohydrates and Kevlar
- ▶ 2 most common types:
 - ▶ Polyesters (ester linkages between hydroxyl and carboxyl groups)
 - ▶ Polyamides (amide linkages between an amine and a carboxylic acid)

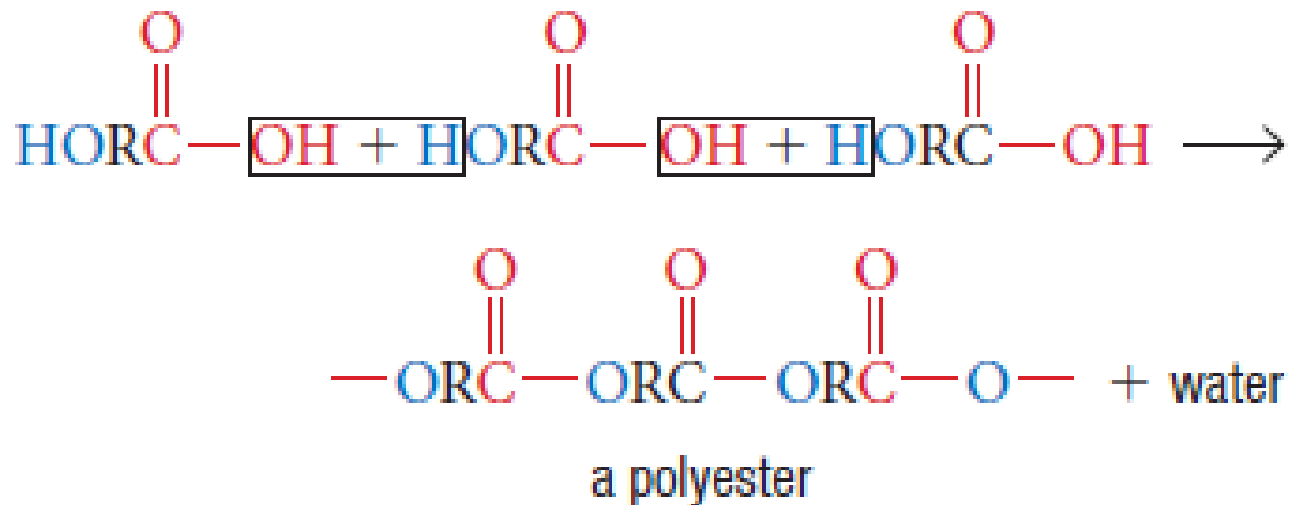


Some condensation polymers feature linkages formed from two hydroxyl groups, like in silicone

CONDENSATION POLYMERS

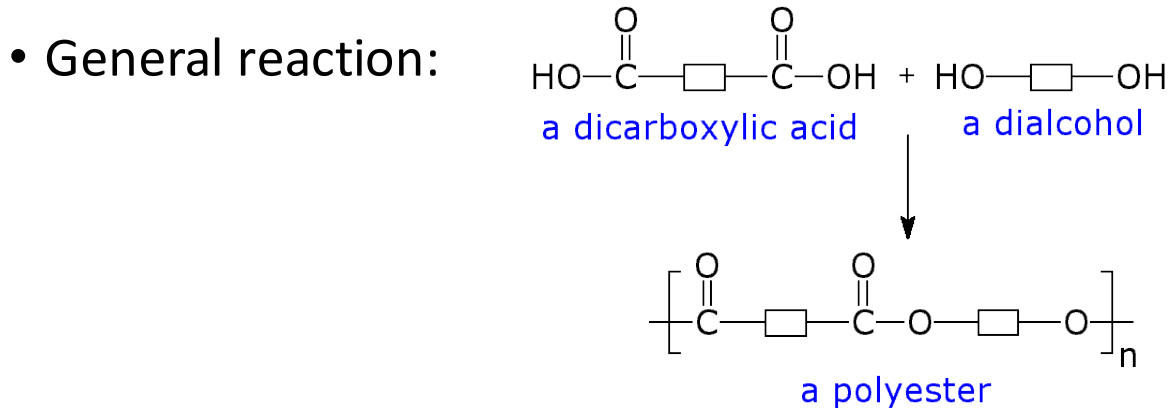
Examples of Polyester from Same Monomer

- General reaction:

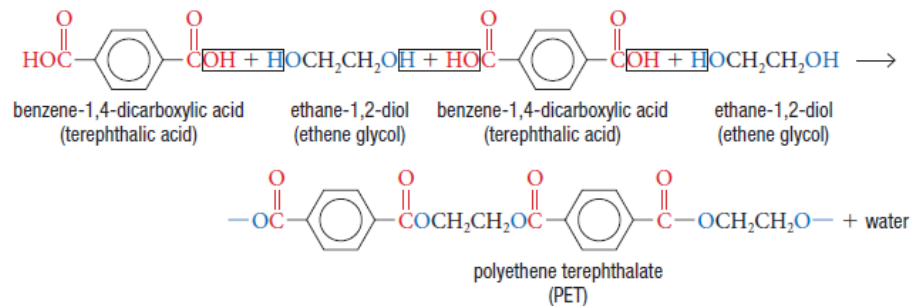


CONDENSATION POLYMERS

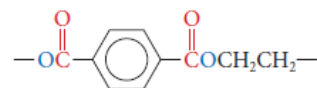
Examples of Polyesters from 2 Different Monomers



- Dacron (polyethene terephthalate):



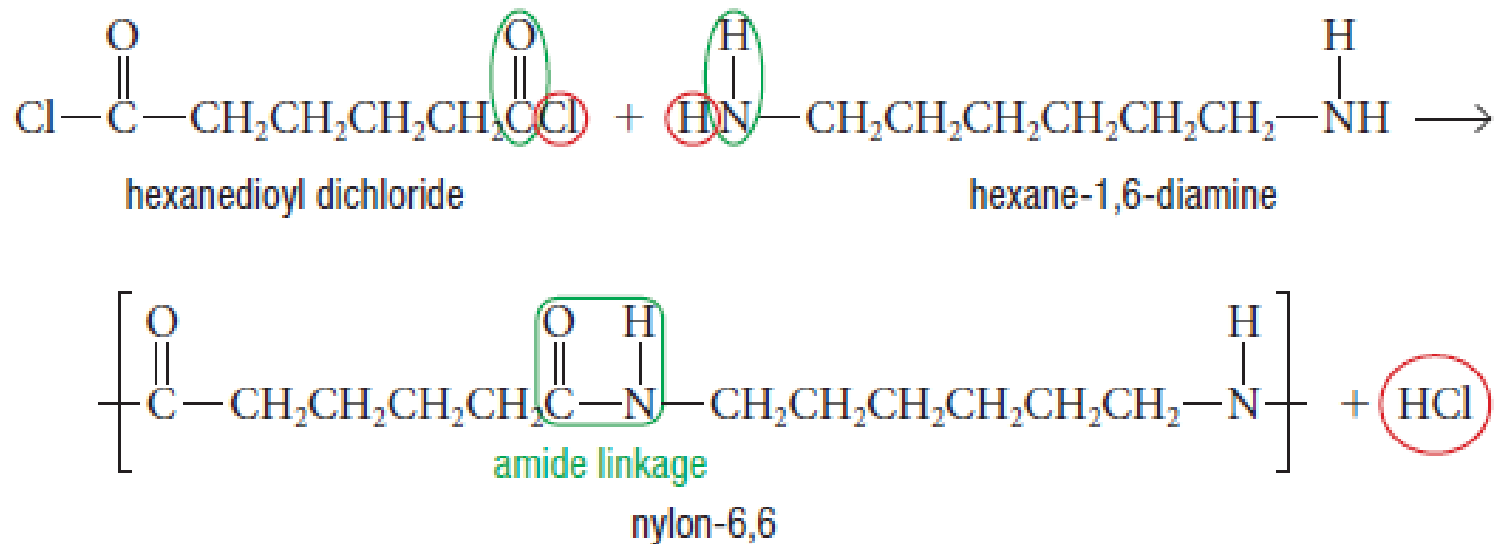
The repeating unit of Dacron is



CONDENSATION POLYMERS

Example of Polyamide

- Nylon 6,6



HOMework

- Page 83 # 1 – 4
- Page 87 # 1 – 3
- Page 93 # 1 – 5
- Page 98 # 1
- Page 99 # 1 – 6