CHAPTER 9 (16)

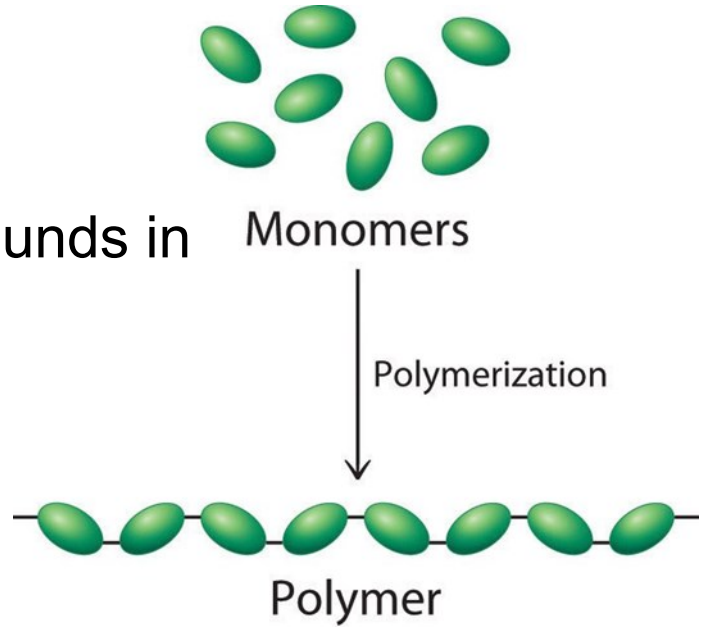
Polymers

What are they?

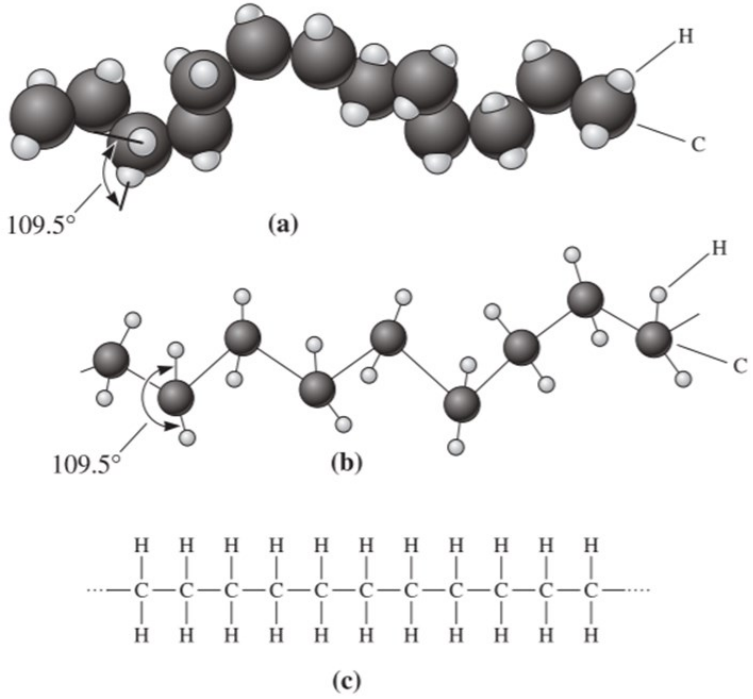
Materials consisting of very large(long) molecules with a molecular weight that varies between 10,000 to over 1’000,000

Concepts

- Monomers: Simple molecules used as the starting compounds in the production of polymers.
- Oligomers: A few units of monomers.
- Polymerization: Process of formation of polymers.



Classification due to Structure

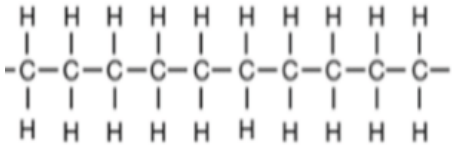


(a) a solid three-dimensional model

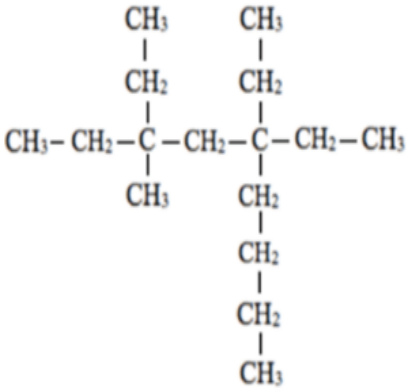
(b) a three-dimensional “space” model

(c) a simple two-dimensional model.

1. Linear

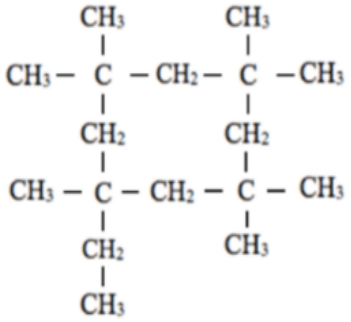


2. Branched



Branched Polymer

3. Cross-linked



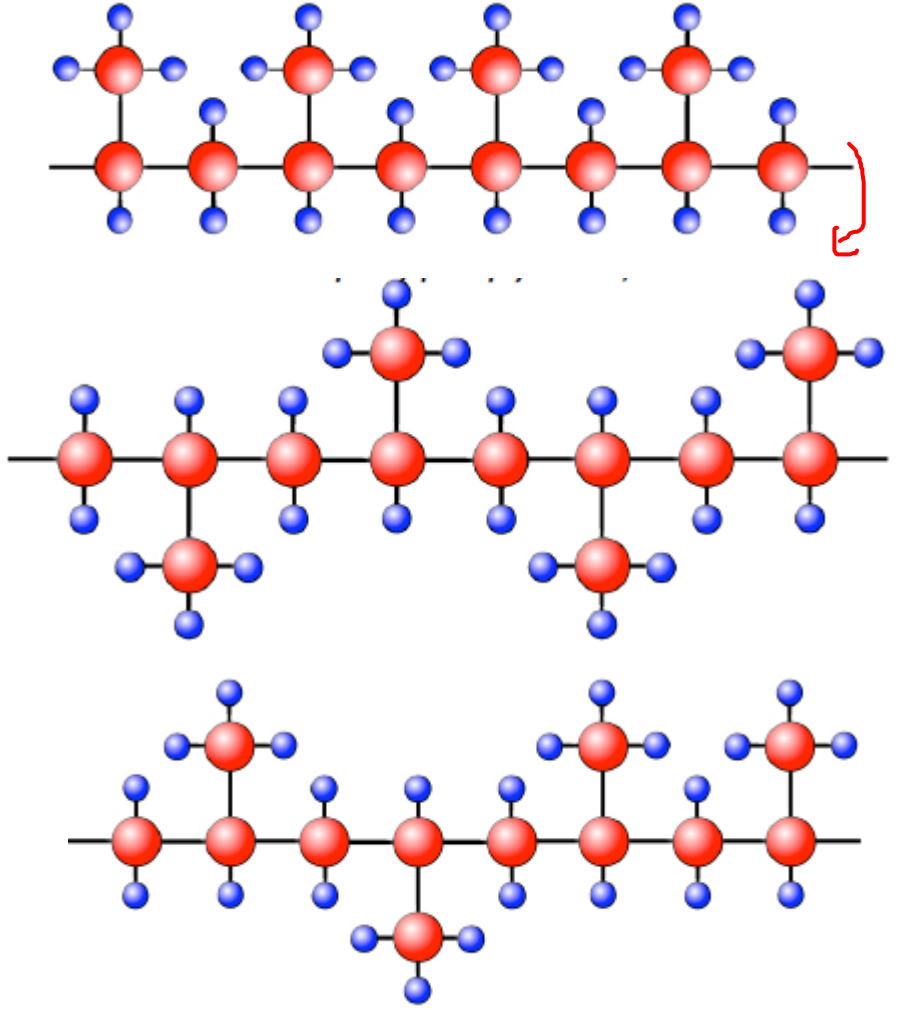
Cross-linked Polymer

Tacticity

Isotactic

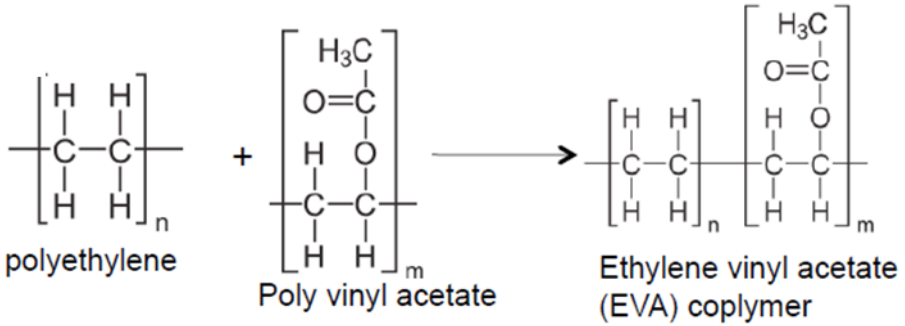
Syndiotactic

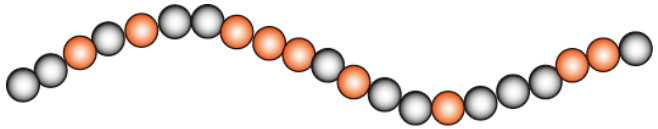
Atactic



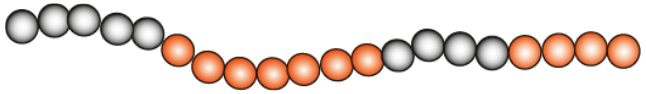
Copolymers

Commercial polymers are composed of different types of unit attached together by chemical covalent bonds.

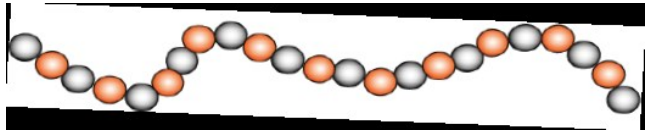




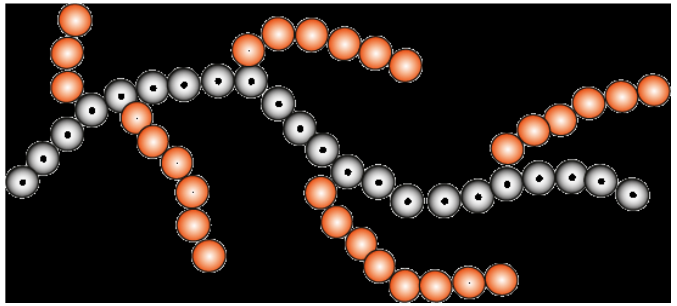
Copolymer with random units



Copolymer with block units



Copolymer with alternating units



Graft copolymers

Classification due to Molecular forces

1. Thermoplastic Polymers- Intermediate forces of attraction. At elevated temperatures they soften and melt. Example: polyvinyl chloride

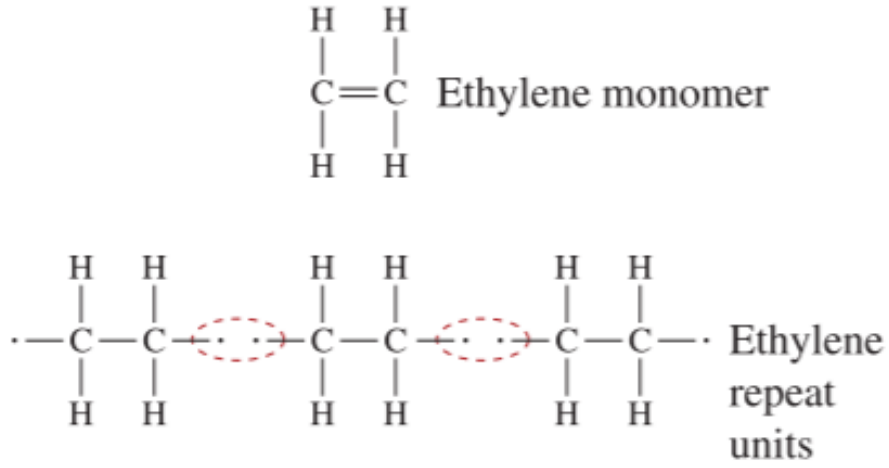
2. Thermosetting Polymers- These polymers greatly improve the material's mechanical properties. At elevated temperatures they cross-link. Further heating leads to their decomposition. For example: phenolics, epoxies, and silicones.

3. Elastomers- These are rubber-like solids weak interaction forces are present. For example: Rubber.

4. Fibres- Strong, tough, high tensile strength and strong forces of interaction are present. For example, nylon -6, 6.

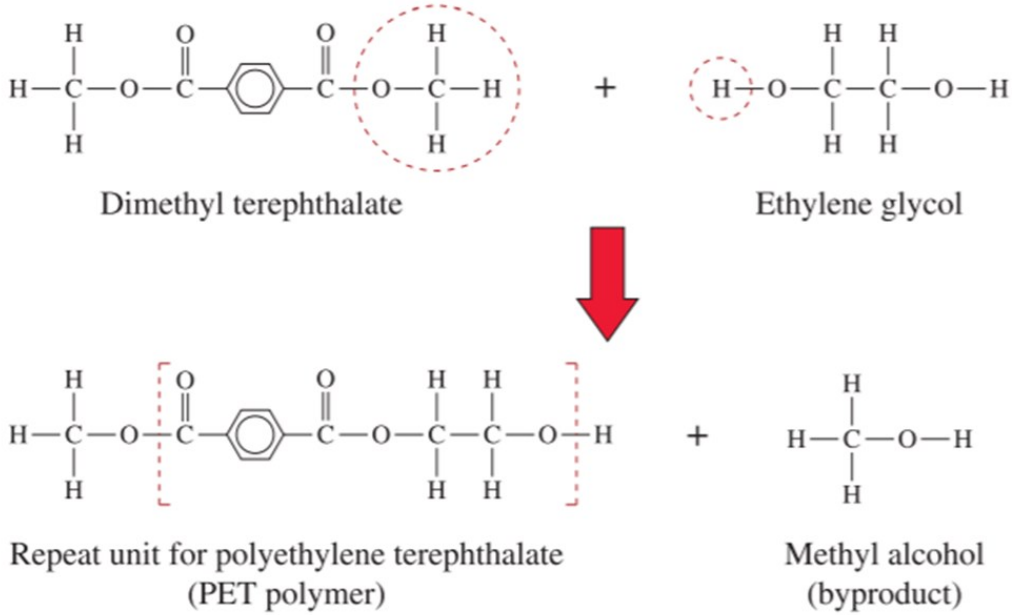
Polymerization: Addition

- **Addition**- The two carbon atoms are joined by a double covalent bond. It can only occur because of double covalent bond between the carbon atoms in the monomer. Example, polyethylene (PE) from ethylene molecules.



Polymerization: Condensation

Condensation- Besides the polymer formation, a relatively small molecule (such as water, ethanol, methanol, etc.) is formed as a result of the polymerization reaction. Example, Nylon.



Polymeric Math

Concepts:

Molecular weight of repeated unit: C+O+H (S-N)

Average Molecular weight of polymer: Weight of the long chain

Degree of polymerization- Average length of a linear polymer. Is also known as Number of units in chain.

$$DP = \frac{Average\ Molecular\ Weight\ of\ Polymer}{Molecular\ weight\ of\ repeated\ unit}$$

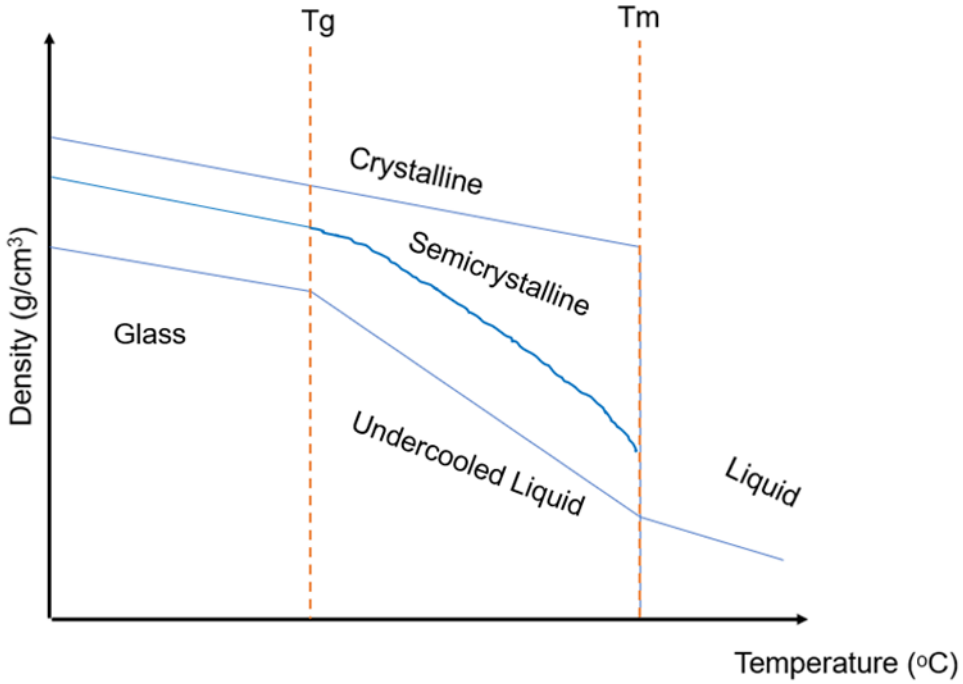
Crystallinity of polymers- Order in the structure of the polymer

$$\%Cr = \frac{\rho_a(\rho - \rho_a)}{\rho(\rho_C - \rho_a)} \times 100\%$$

ρ_a: Density of amorphous polymer

ρ_C: Density of crystalline polymer

ρ : Density of actual polymer



Important concepts Recap

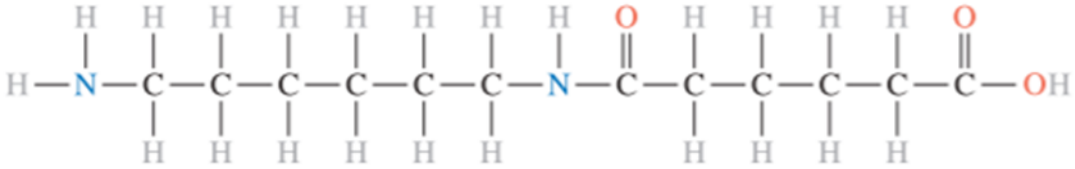
Addition	Condensation
No byproduct	Byproducts (H_2O, C-OH, C-NH)
Double bond	Functional groups (COOH, $CONH_2$,CNH_2)
No need for heat or additional catalysts	Need energy

$$DP = \frac{Average\ Molecular\ Weight\ of\ Polymer}{Molecular\ weight\ of\ repeated\ unit}$$

$$\%Cr = \frac{\rho_a(\rho - \rho_a)}{\rho(\rho_C - \rho_a)} \times 100\%$$

Example

- Calculate the degree of polymerization of 6,6- Nylon if the molecular weight is 120,000. What type of polymerization is it? How many monomeric chains are in 1g of polymer?



Hexamethylene diamine

Adipic acid

$C_6H_{16}N_2$

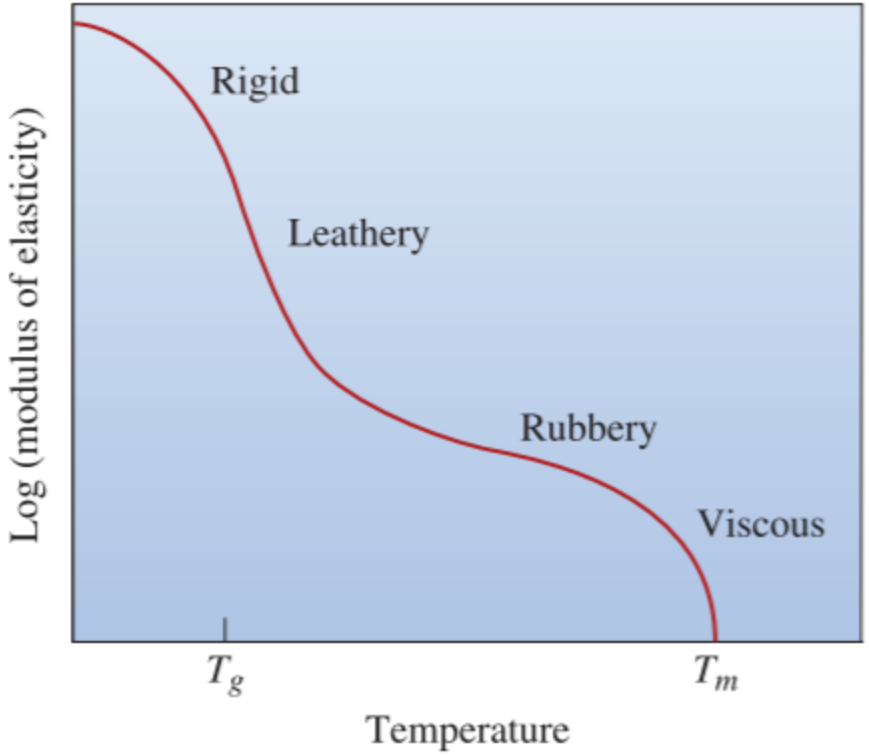
$C_6H_{10}O_4$

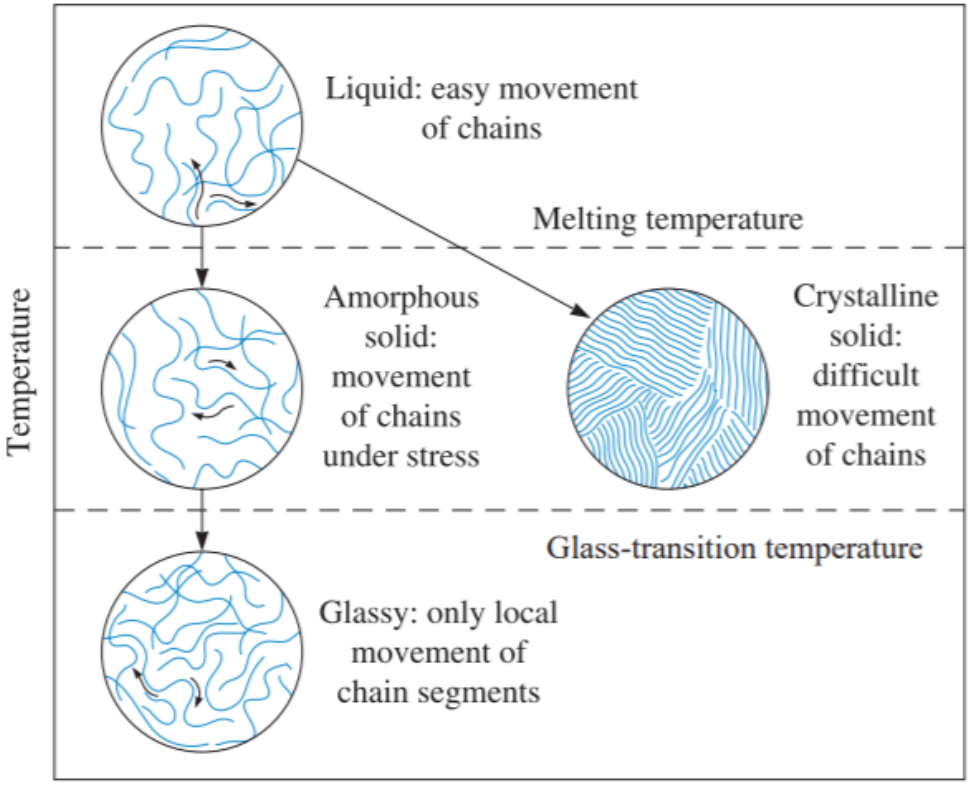
- $M_1=C_6H_{16}N_2$
-$M_2=C_6H_{10}O_4$
Average molecular Weight=120000
C=12
H=1
O=16
N=14

- $M_1=C6H16N2$
-$M_2=C_6H_{10}O_4$
C=12
H=1
O=16
N=14

Thermoplastic Polymers

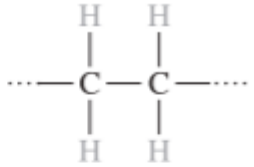
- Linear or branched polymers in which chains of molecules are not connected to one another



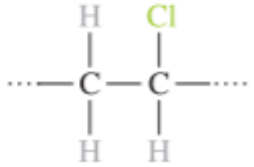


Typical Thermoplastics

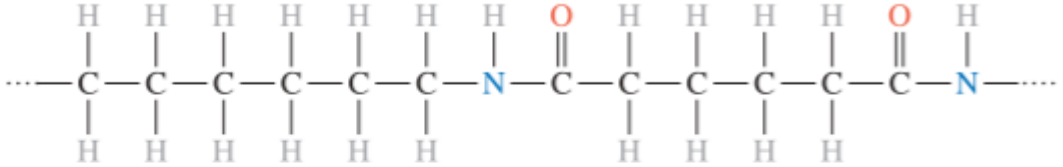
Polyethylene (PE)



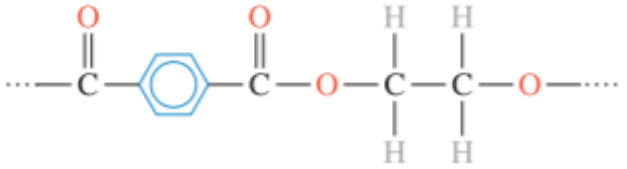
Polyvinyl chloride (PVC)



Polyamide (nylon) (PA)



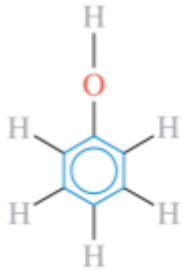
Polyester (PET)



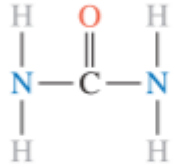
Thermosetting Polymers

- Highly cross-linked polymers that form 3D network structures
- - Crosslinking requires heat or an additional agent
- - Crosslinking is not reversible. Not Environmentally friendly

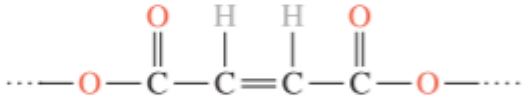
Phenolics



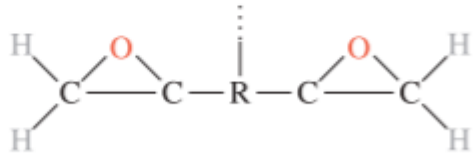
Amines



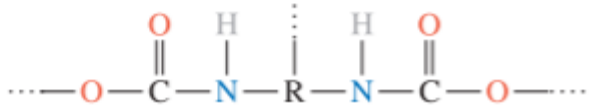
Polyesters



Epoxies



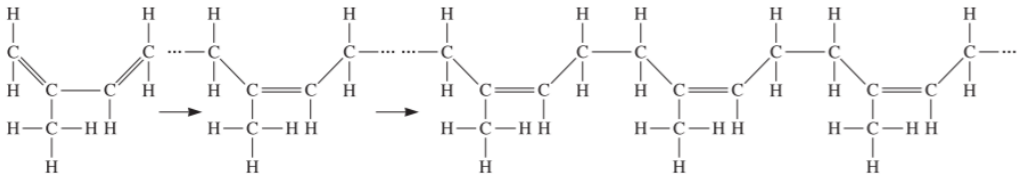
Urethanes



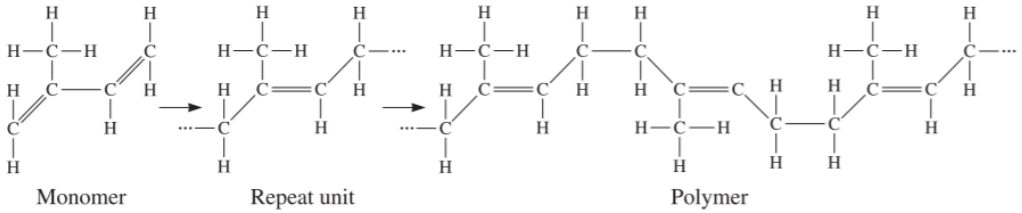
Elastomers (Rubbers)

- Natural and synthetic polymers which display elastic deformation when a force field is applied.
- Natural:

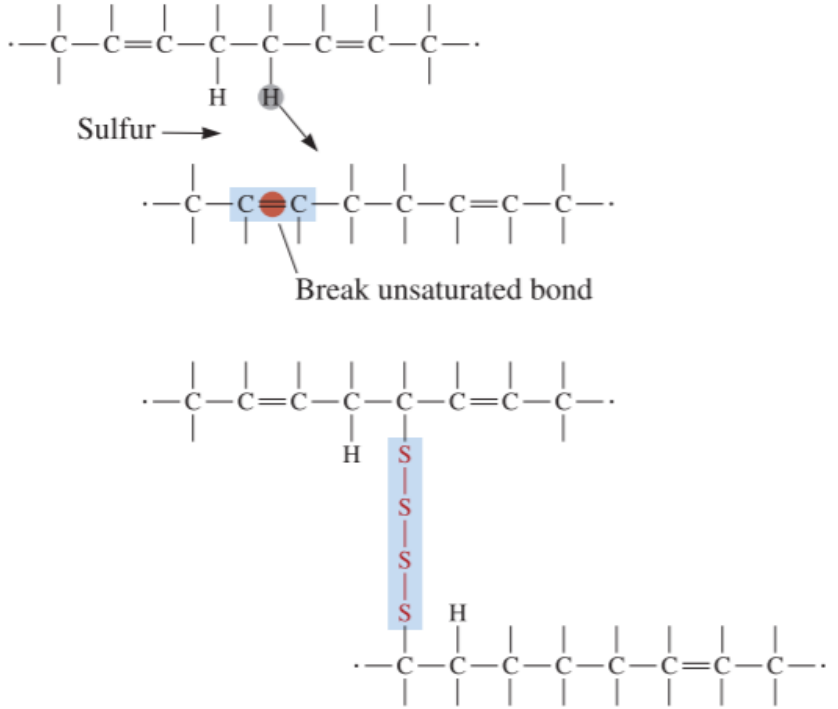
Cis



Trans



Synthetic:



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