Chap 10
Polymers

1. polymers- from Greek meaning "poly" many and "meros" meaning many parts.
   made from smaller molecules called monomers.
   How to write polymers-\(-{(CH_2-CH_2)}_n\) means that this is the repeating monomer.
   Ex. 10.2 CH$_2$=CHF is the monomer.

   The polymer is

2. Thermoplastic and thermosetting polymers.
   a. Thermoplastic polymer- can be softened by heat and pressure and then reshaped. Linear or branched polymers can slide past each other.
   b. thermosetting polymers- harden permanently when formed. Due to cross linking of the polymer.

3. Glass transition temp. $T_g$ Above this tempo the polymer is rubbery and below is tough like glass, stiff and brittle. For tires we want low $T_g$.

3. Crystalline and amorphous polymers-
   a) Crystalline polymers- molecules line up neatly to form long fibers of high tensile strength. Make good synthetic fibers.
   b) amorphous- composed of randomly orientated molecules that get tangled up. Make elastomers.
Spandex is a mixture of both. Spandex for ski pants and exercise clothing, blocks of one polymer with other blocks.

4. Composites- high strength fibers (of glass, graphite, or ceramics) held together by a polymeric matrix, usually a thermosetting condensation polymer

3. Natural polymers- get overview of table 10.1
   a. Starch- made up of glucose molecules.
   b. Cotton is made of cellulose- also glucose but different connectivity.
   c. wood is mostly cellulose.
   d. Proteins are amino acids. Also wool and silk.
   e. DNA

3. Cellulose- a derivative of a natural one.
   a. Celluloid derived from cellulose and treated with nitric acid to get cellulose nitrate. To find a substitute for ivory billiard balls in a contest treated cellulose nitrate with ethyl alcohol and camphor to soften it. Which then could be molded into billiard balls. Made it a game for everybody. Celluloid was also used for film and stiff collars. Today movie film is made with cellulose acetate.

4. Polyethylene- made from ethylene CH₂=CH₂,

   Addition polymer
   A + A ⊕ A-A + A ⊕ A-A-A + A
   a. First uses to insulate cables in radar in WW II. For Battle of Britain.
   b. Two major types
      1. HDPE- (high density) linear molecules that pack well. Are rigid and have good tensile strength. Used in bottle caps, toys, gallon milk jugs.
      2. LDPS- (low density) have lots of branching side chains. Cannot pack as well, are bendable and waxy. Plastic bags, plastic film, squeeze bottles, electric wire insulation.
3. LLDPE- linear low density polyethylene, a copolymer of ethylene with a higher alkene such as 1-hexene. More than 70% is used to make film.

5. Polypropylene- a tough plastic that resists moisture, oils, and solvents. Molded into hard-shell luggage, battery cases, appliance parts. Carpets, upholstery fabrics.

6. Polystyrene- used in throw away plastic cups, inexpensive toys and household items, Styrofoam cups.

7. Polyvinyl chloride- PVC –(CH₂=CHCl)- monomer is a gas at room temp. makes a thermoplastic material, clear rigid material for bottles, long lasting floor covering, fake wood, artificial leather, lightweight, 40% rustproof plumbing. Beach chair webbing,

8. Teflon- strong C-F bond is resistant to heat and chemicals, un-reactive, nonflammable

10. Rubber- type of polymer- elastomer- During WWII Japanese cut off the supply of rubber in Malaysia and Indonesia, need a synthetic substitute.

A) Natural rubber- isoprene is a volatile liquid. Can make isoprene from petroleum refineries.

Polymer

Vulcanization- natural rubber is soft and tacky when hot, can be made harder by reaction with sulfur called vulcanization. Patent 1844.
Cross linking made the rubber harder for tires, also made it more elastic. Right amount of cross linking individual chains can coil and uncoil and stretch.

B) Synthetic rubber- main use of elastomers is tires.

1) butadiene Monomer- \( \text{CH}_2=\text{CH}-\text{CH}2 \)

makes the polymer butadiene \(- (\text{CH}_2-\text{CH}=\text{CH}-\text{CH}_2)\)- poor tensile strength and poor resistance to gasoline and oils.

2) Neoprene- monomer \( \text{CH}_2=\text{CCl}-\text{CH}2 \)

Polymer \(- (\text{CH}_2-\text{CCl}=\text{CH}-\text{CH}_2)\)- uses include gas hoses.

3) SBR copolymer 25% styrene and 75% butadiene, can be cross linked, manly for tire making
10. Silicones- polymer based on alternating O and Si. Can be cross linked or linear. heat stable and make good water proofing.

![Si-O-Si-O](image)

made into Silly Putty. Also for body parts, finger joints, artificial ears and breasts.

9. Condensation polymers- a small molecule is split out during polymerization, usually water.

\[ A + A \rightarrow (A-A + H_2O) + A \rightarrow A-A-A + H_2O \]

A) Nylon- forms amide bonds-

6-aminohexanoic acid

![6-aminohexanoic acid](image)

Two different polymers.

![Two different polymers](image)

original nylon polymer in 1937, nylon 6,6, made into carpets.
b) Polyester- ethylene glycol with terephthalic acid most common to form Polyethylene terephthalate (PET) can be molded into bottles, used for cassette tapes, and clothing.

c) Resigns- 1909 patent