Institute Core Course for BTech Program

IC250: Materials Chemistry II

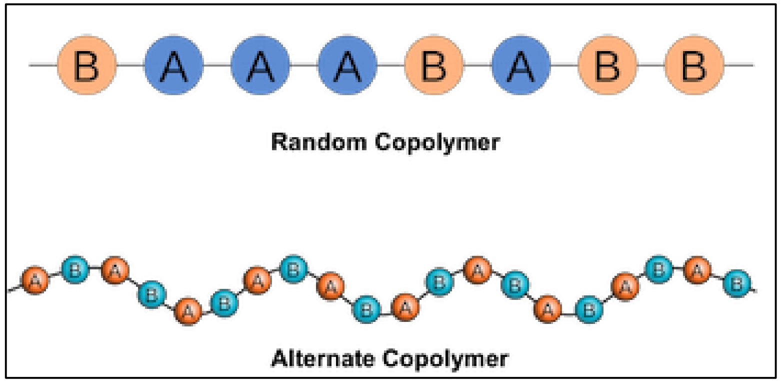
Dr. Arup Mukherjee

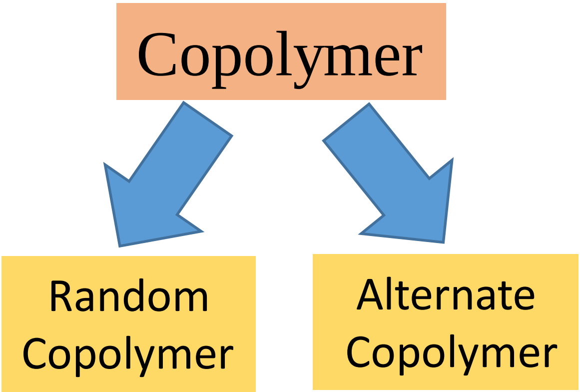
Assistant Professor

Department of Chemistry

Polymers

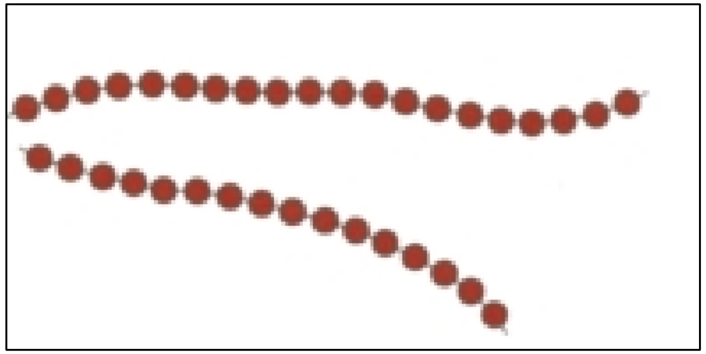
- Polymers are made of basic units called *mers*
- When a structure consists of only one *mer*, it is a monomer. If it contains more than one *mer*, it is called a polymer
- Isomers are molecules that contain the same number of similar *mers*, but the arrangement is different, e.g.: Butene and Isobutene.
- When a polymer has ONE kind of *mers* in its structure, it is called homopolymer.
- Polymer made with more than one kind of *mers* is called copolymer.



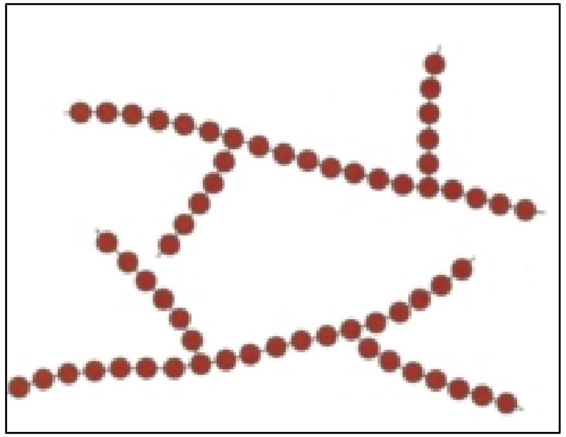


Polymer Structures

- **Linear:** Here the *mer* units are joined together end to end in single chains. E.g.: PVC, nylon.

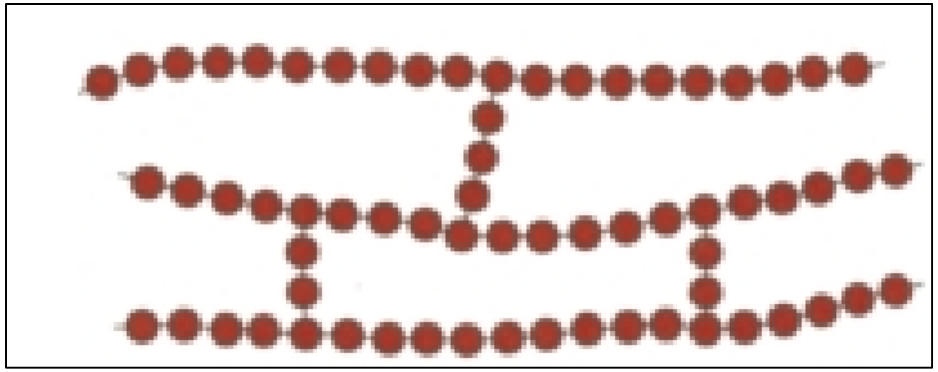


- **Branched:** Here side-branch chains are connected to main ones. Branching of polymers lowers polymer density because of lower packing efficiency.

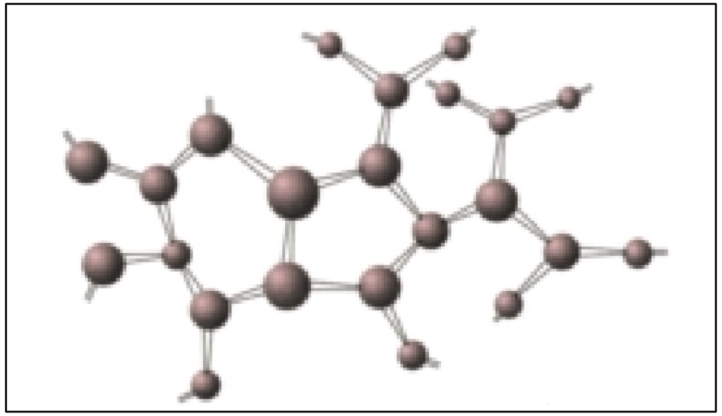


Polymer Structures

- **Cross-linked:** Here chains are joined one to another at various positions by covalent bonds. This cross-linking is usually achieved at elevated temperatures by additive atoms. E.g.: vulcanization of rubber.



- **Network:** Trifunctional *mer* units with 3-D networks comes under this category. E.g.: epoxies, phenol-formaldehyde.

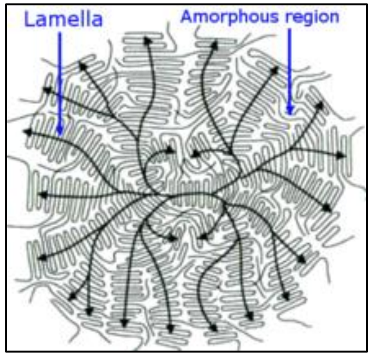


Thermo-Sets and Thermo-Plasts

- Mechanical response of polymers at elevated temperatures strongly depends on their chain configuration. Based on this, polymers are grouped in two types:
- **Thermo-Sets:** They become permanently hard when heated, and do not soften during next heat cycle. During initial heating, extensive covalent cross-linking takes place. They are stronger and harder than thermo-plasts. E.g.: Vulcanized rubber, epoxies, some polyester resins.
- **Thermo-Plasts:** They softens at high temperatures (eventually liquefy), and becomes hard at ambient temperatures. The process is reversible. Usually made of linear and branched structures. E.g.: Polystyrene, Acrylics, Cellulosics.

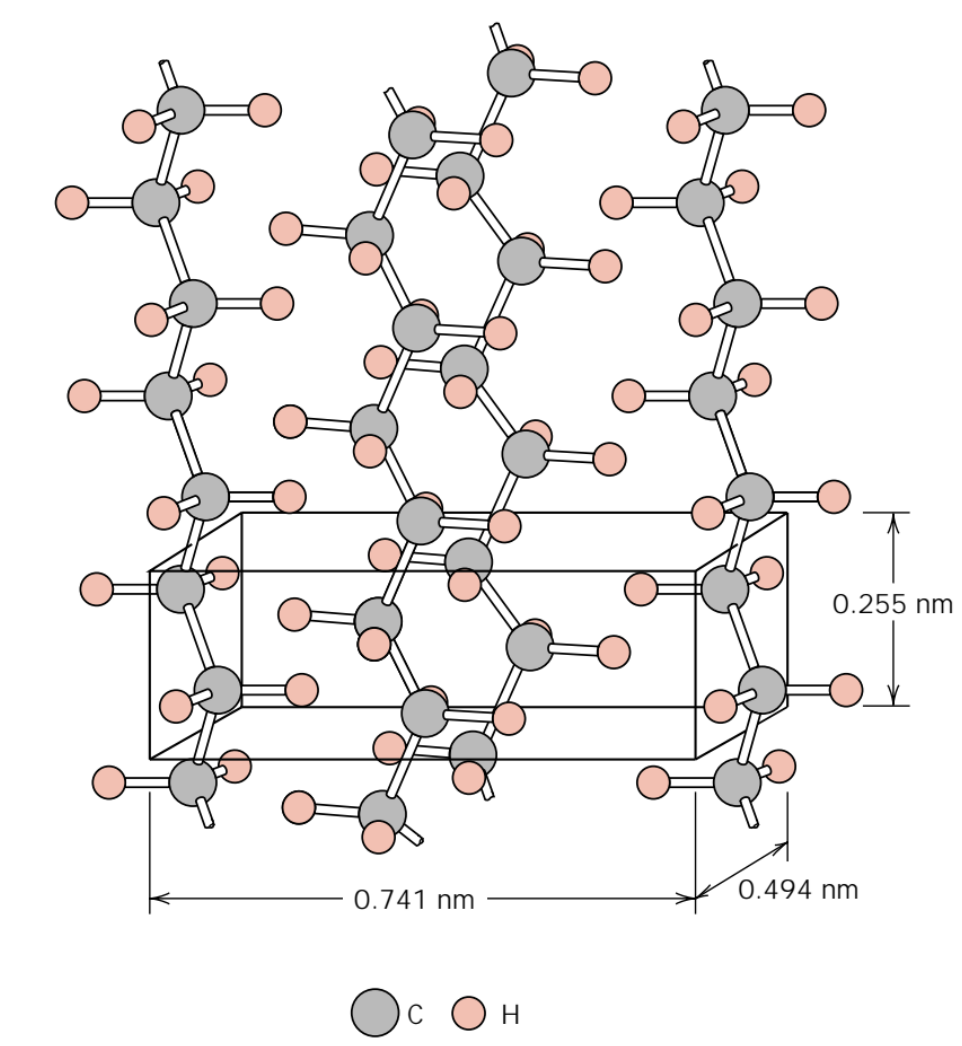
Polymer Crystallinity

- Polymer crystallinity is the packing of molecular chains to produce an ordered atomic array. Crystallinity in polymers is more complex than in metals.
- Polymer crystallinity range from almost crystalline to amorphous in nature.
- It depends on cooling path and on chain configuration.
- Crystalline polymers are more denser than amorphous polymers.
- Many semicrystalline polymers form *spherulites*. Each *spherulite* consists of collection of ribbon like chain folded lamellar crystallites. E.g.: PVC (Poly Vinyl Chloride)



- *Spherulites* are spherical semicrystalline regions inside non-branched linear polymers.

Polymer Crystallinity



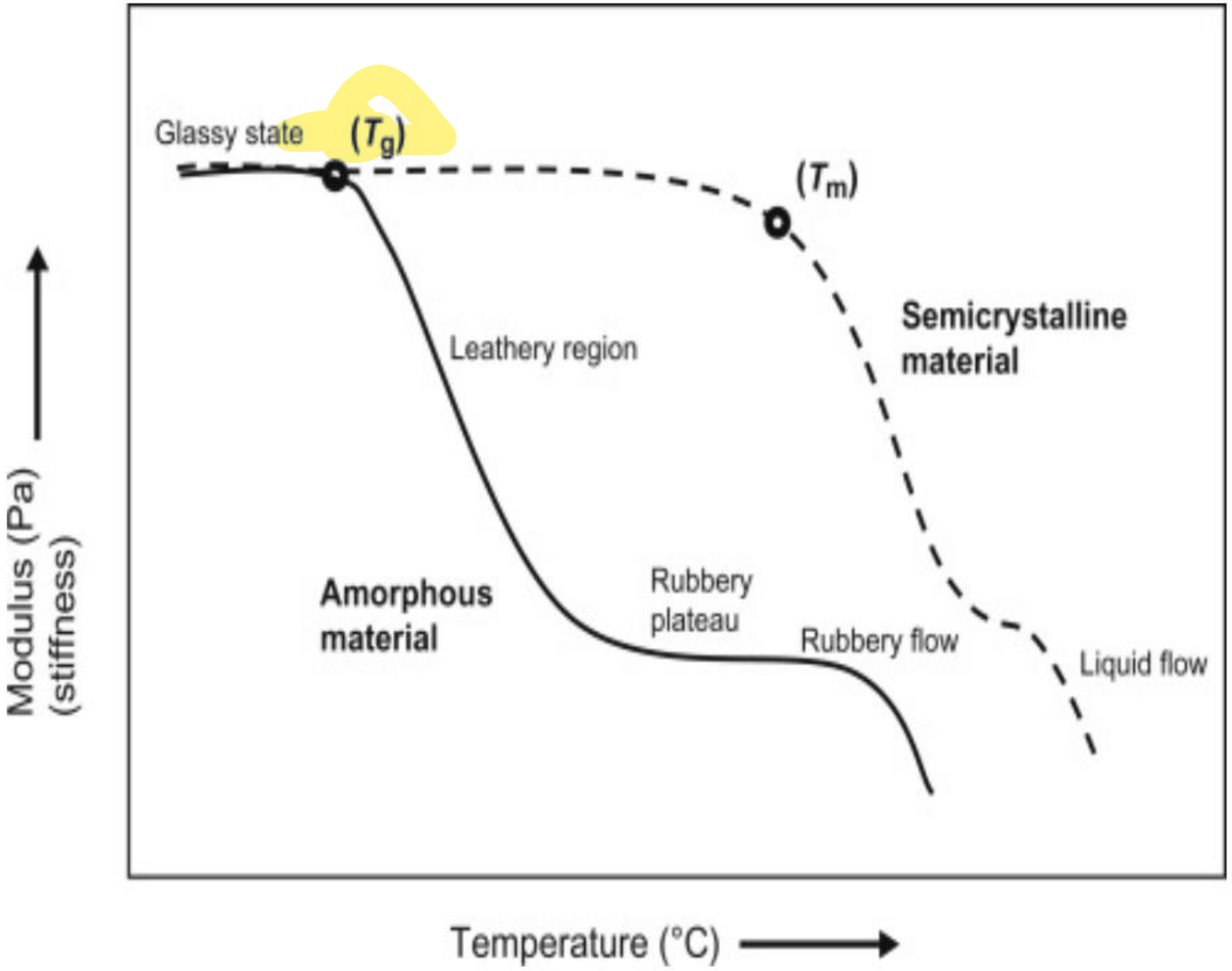
Arrangement of molecular chains in a unit cell for polyethylene.

- The degree of crystallinity by weight may be determined from accurate density measurements, according to

$$\% \text{ crystallinity} = \frac{\rho_c(\rho_s - \rho_a)}{\rho_s(\rho_c - \rho_a)} \times 100$$

where ρ_s is the density of a specimen for which the percent crystallinity is to be determined, ρ_a is the density of the totally amorphous polymer, and ρ_c is the density of the perfectly crystalline polymer.

Glass Transition Temperature (T_g)



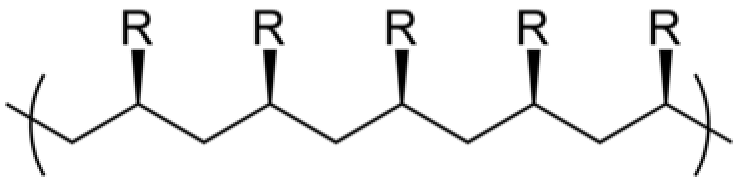
- Process of conversion of crystalline to glassy solid is called **Vitrification**.

Glass Transition Temperature (T_g)

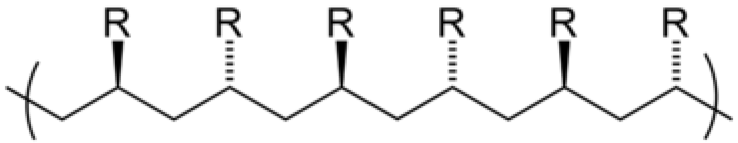
Factors affect the T_g:

1. Crystallinity
2. Molecular Mass
3. Presence of side chain
4. Presence of plasticizer
5. Stereo regularity

Isotactic polymers



Syndiotactic polymers



Atactic polymers