Physical properties – strength

It depends upon the magnitude of force of attraction between polymeric chains

- Two types (a) Primary or chemical bond and (b) Secondary or intermolecular forces (van der Wall force or hydrogen bonding)
- In a cross-linked polymers, all chains are interconnected by strong chemical covalent bond, resulting in a giant solid molecule, extending in three dimensions
- So they are strong and tough materials, since the movement of intermolecular chains are totally restricted

- In linear or branched polymers, the chains are held together by weak intermolecular force of attraction (secondary), strength increases with increase in chain length or molecular weight

- Polymers of lower chain length are soft and gummy, while higher chain polymers are hard and strong
- By controlling the chain length, the strength of the polymer can be varied from *soft and flexible* to *hard and born* like substances
- Strength of the polymer can be increased by increasing the intermolecular force by the introduction of groups like carboxyl, hydroxyl, chlorine, fluorine, nitrile along the chain

_ Strength of linear chain polymers also depends upon the slipping power of one chain over the other

_ *Shape of the polymer affects the resistance to slip and consequently the*
deformation of the polymer

- Take PE and PVC, PE is simple and uniform, but PVC has large lumps of C*l* atoms, periodically along its chains with results that (i) movement of chains is restricted (ii) Strong secondary intermolecular force of attraction due to the electronegativity difference between H and C*l* atoms
- So PVC is more hard and strong polymer than PE

Deformation

- Deformation is the slipping of one chain over the other *(on the application of heat or pressure or both)* or stretching and recoverance of original shape of the polymeric chains *(after the removal of stress)*

- Two types
  - Plastic Deformation (Plasticity)
  - Elastic Deformation (Elasticity)

- ***Plastic Deformation (Plasticity)*** is the slipping of one chain over the other on the application of heat or pressure or both

- It occurs only when the weak secondary intermolecular force is operating between the polymeric chains, when sufficient load is applied permanent deformation occurs as slippage

- The linear or branched polymers show the greatest degree of plastic deformation

- This type of material, in heated state, readily takes the shape of the mould, when it is injected into under pressure, called thermoplastic.

- At high temperature, polymers deform easily due to the weakening of secondary intermolecular force between chains so the chains can easily slip over each other.

- On cooling, the polymer becomes rigid in the moulded shape, because plasticity decreases with fall of temperature.

- So plasticity of the polymer is reversible.

- _ ***Elastic Deformation (Elasticity)*** is the stretching and recoverance of original shape of the polymeric chains after the removal of stress

- It arises from the fact that long polymeric chains having free rotating groups which assume peculiar configuration of irregularly coiled and entangled snarls in unstressed condition, lead to amorphous state of polymer

- When such a polymer is stretched, the snarls begin to disentangle (like a spring) and straighten out, which in turn enhances the attraction force between chains, thereby causing stiffening of polymer

- When stress is released, the stretched snarls return to their original Arrangement.

Chemical Resistance and Solubility

- Chemical attack is internal, causing softening , swelling and loss of strength of polymer.

- The chemical nature of monomeric units and their molecular arrangement determines the chemical resistance of the polymer.

- Polymers having polar groups (-OH, –COOH, or Cl) swollen or even dissolved in polar solvents whereas polymers having nonpolar groups ($-CH_3$ or $-C_6H_5$) swollen or even dissolved in non polar solvents.
- polymers of more aliphatic character are more soluble in aliphatic solvents whereas polymers of more aromatic character are more soluble in aromatic solvents.

- The tendency to swell or solubility of polymers decreases with the increase in chain length or molecular weight of polymer

_ High molecular weight polymers, on dissolving yield solutions of high viscosities.

- In crystalline polymers, denser close packing of polymeric chains makes the penetration of solvents or chemical reagents in the polymeric material more difficult, so crystalline polymers exhibit more chemical resistance or lesser solubilty.

- Greater the degree cross-linking in the polymer, lesser is its solubility and greater is its chemical resistance.