

Interpolymer bonding

- In basic senses these bonds are responsible for holding the polymers together for the formation of a fibre. The major bonds used for interpolymer bonding are as follows,
- Van der Waals' forces
- Hydrogen bonds
- Salt linkages
- Cross links

Van der Waal's forces

- They are weak inter-polymer forces of attraction, named after the Dutch physicist Johannes Diederik vander Waals who first found out their existence.
- When the two or more atoms are close enough together, then these forces will come into existence.
- They are formed between atoms along the length of adjacent polymers when these are less than 0.3 nm apart but no closer than about 0.2 nm.
- They occurs between the polymers of all fibers. Their bond energy or bond strength is 8.4 KJ, and relative strength is very weak.
- They are the only interpolymer force of attraction existing in the polymer system of polyethylene, polypropylene, polyvinylchloride, polyvinylidene chloride, primary cellulose acetate and 100 percent polyacrylonitrile fibers.
- They are considered to be the predominant inter-polymer force of attraction in the polymer system of acrylic, mod-acrylic and polyester fibres.

- It may be assumed that van der Waal's forces exist between the polymers of crystalline regions of any fibre's polymer system.
- Larger atoms give rise to stronger van der Waal's forces than smaller atoms. For example: the hydrogen atom is the smallest, being about 0.06 nm in diameter ; and chlorine atom is about 0.2 nm, i.e. more than three times as large in diameter. Consider the polymer system of polyethylene and polyvinylidene chloride fibres. Because of the presence of chlorine atoms on the polyvinylidene chloride polymers, the van der Waal's forces formed in the polymer system of this fiber will be stronger than those formed in polyethylene.
- The influence of the difference in strength of the van der Waal's forces in the two fibres is seen by their melting points. The stronger the interpolymer forces of attraction, the higher the melting point of the polymer system.
- Polyethylene : 110-140* C; polyvinyl chloride: 170-200*C

Hydrogen bonds

- These are written as H- bonds and are weak electrostatic bonds.
- They are formed between hydrogen and oxygen atoms, and hydrogen and nitrogen atoms on adjacent polymers when these are less than 0.5 nm apart.
- The hydrogen-oxygen bond is stronger than the hydrogen-nitrogen bond because nitrogen becomes less electronegative than oxygen.
- H-bond is formed when two atoms, say hydrogen and oxygen , must develop very slight, but opposite charges or polarity. The development of polarity may be explained by considering the H-bond between the imino hydrogen of an amide or peptide group on one polymer, and the carbonyl oxygen on an amide group on a very closely adjacent polymer.

- They occur within the natural polymers, regenerated cellulose polymers, nylon polymers, polyvinyl alcohol, polyester polymers, protein and secondary cellulose acetate fibres.
- Their bond energy is 20.9 KJ and relative strength is weak.
- The hydrogen bonds are mainly responsible for the tenacity and the elastic-plastic nature of the natural, regenerated cellulose, nylon, PVA and protein fibres.
- H-bonds occurring in the polymer system of polyester fibres are very weak and not considered to be important; insignificant H-bonds are formed in the polymer system of secondary cellulose fibres. There is doubt about H-bonds formation in the polymer system of acrylic and modacrylic fibres.
- The presence of H-bonds also indicates the existence of polar sites along the polymer lengths. Polar sites will attract the water molecules. Thus, if the polymer attracts water molecules, the polymer system will be hydrophilic, and fiber will be comfortable to wear.

Salt linkages

- Also called salt links or salt bridges, and are electrovalent or ionic bonds. They occur between $-$ vely & $+$ vely charged radicals on very closely adjacent fibre polymers.
- Atoms may also gain or lose electrons. Such a gain or loss alters the normal complement of electrons of the atom. It is called an ion, i.e. it is either a $+$ vely or $-$ vely charged atom. That's why salt linkages are also called ionic bonds, or electrovalent bonds.
- If the radicals of the fiber polymers carry only one charge, i.e. one $-$ ve and one $+$ ve sign, they will form only one electrovalent bond or salt linkage.
- They are formed between the carboxyl radical on one polymer and the positively charged amino group on an adjacent polymer.
- They exist mainly in the polymers of protein and nylon fibres.
- Their bond energy is 54.4 KJ and relative strength is strong.

- They contribute towards the tenacity, elastic-plastic nature, and durability of the fiber and its textile material. They attract the water molecules, hence, enhance the hygroscopic nature of the fiber.
- The presence of salt linkages is necessary for dye absorption as they attract the anion of acid dyes.
- It will also be found that fibres, whose polymer systems contain salt linkages, will be more reactive than those inter-polymer forces of attraction.

Cross links

- **Cross-link** is a bond that links one polymer chain to another. They are covalent or valence bonds and, more specifically, single covalent bonds.
- Single covalent bonds occur not only within fibre polymers, but also at selected points between the polymers in such fibres as elastomeric, wool, mohair, but not in silk. They are formed as a single covalent bond between adjacent polymers of wool due to the disulphide bond or cross-link, also formed in elastomeric, but details not known.
- When single covalent bond link adjacent polymers, they are called cross-links.
- The number of cross-links or the amount of cross-linking between polymers in a polymer system is known as degree of cross-linking.
- The degree of cross-linking in the polymer system of a fiber influences the fiber's elastic-plastic nature and tenacity.
- The greater the degree of cross-linking, the stiffer, less flexible, more rigid will be the fibre.

- Their bond energy is 245.3 KJ and relative strength is very strong.
- They contribute to the elastic nature of elastomers; the tenacity of wool; are broken and re-formed under controlled conditions for heat and chemical setting of wool and other protein fibres, but not silk.