

The structure of polymers for production of fibers:

Cristalinity, orientation, tensile strength procedures, molecular weight and chain structure, lineer symmetry, molecular flexibility.

The structure of polymers for production of fibers

Organochemical structure

It covers the chemical nature of repeating unit and bonds present in the polymer chains.

It affects;

- Dyeability
- Moisture absorption
- Swelling

Macromolecular structure

It investigates the polymer chains as a whole, and covers the concepts of chain length, chain flexibility, distribution of chain length, and chain shape of a polymer.

It affects;

- Dyeability
- Moisture absorption
- Swelling

Supramolecular structure

It covers the 3-D appearances of the polymer chains.

These structures effect directly the physical properties, and indirectly chemical properties of the fibers.

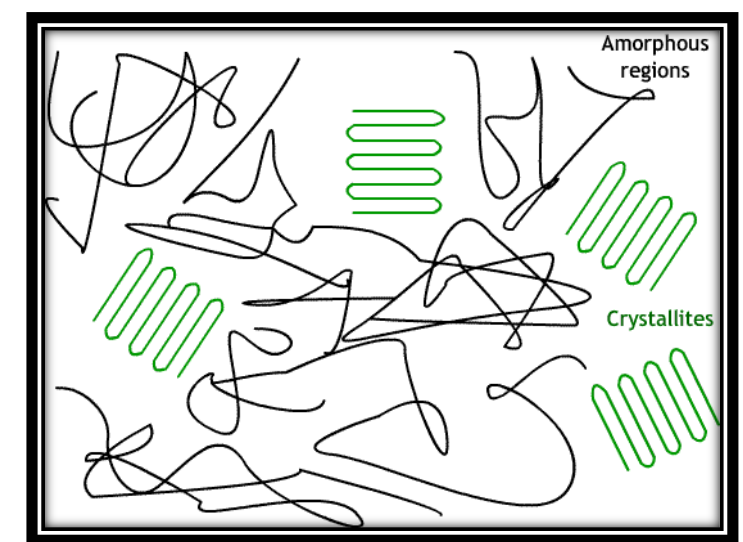
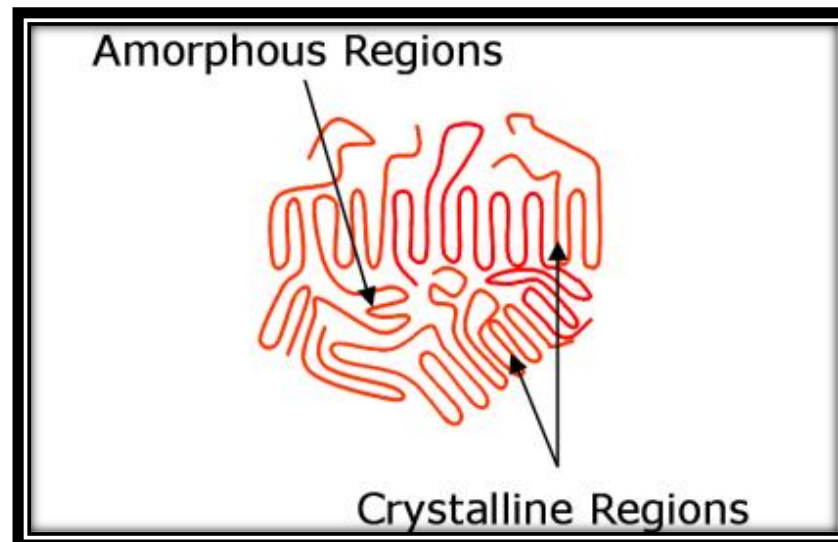
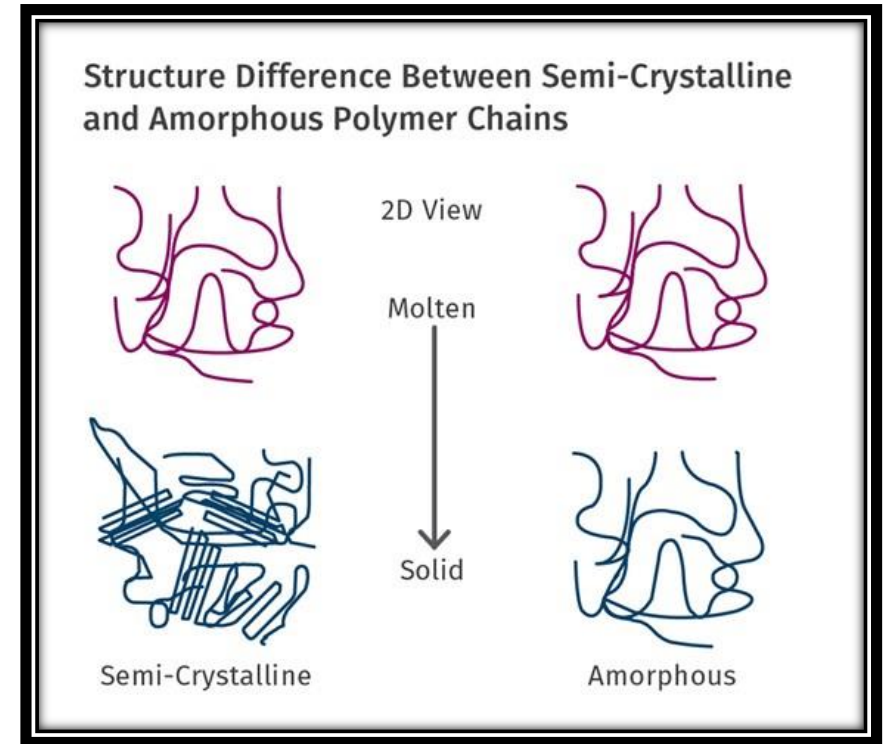
Crystallinity

Polymers can be fully amorphous, semi-crystalline, and fully crystalline.

Amorphous polymers....> polymer chains are randomly mixed with each other

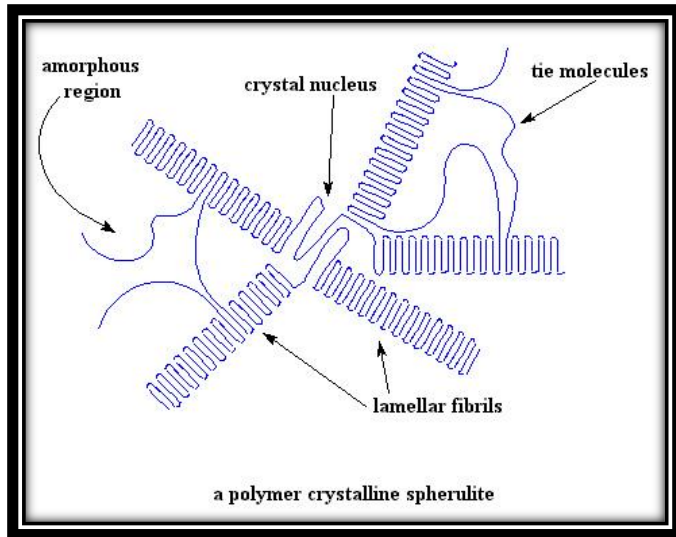
Fully crystalline polymers...> polymer chains that are packaged orderly take a geometry suitable for crystal structure

Textile fibers are in the **semi-crystalline** structure



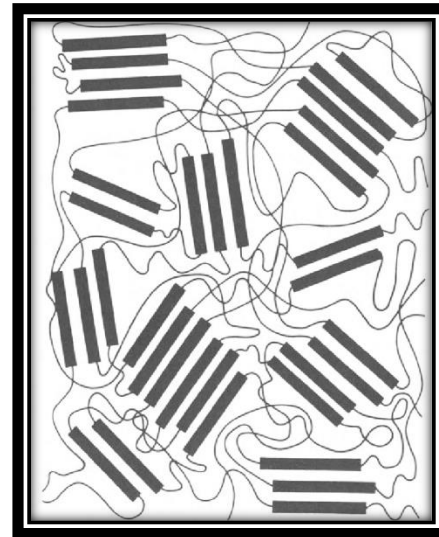
The crystalline models used in the semi-crystalline polymers

Spherulite model



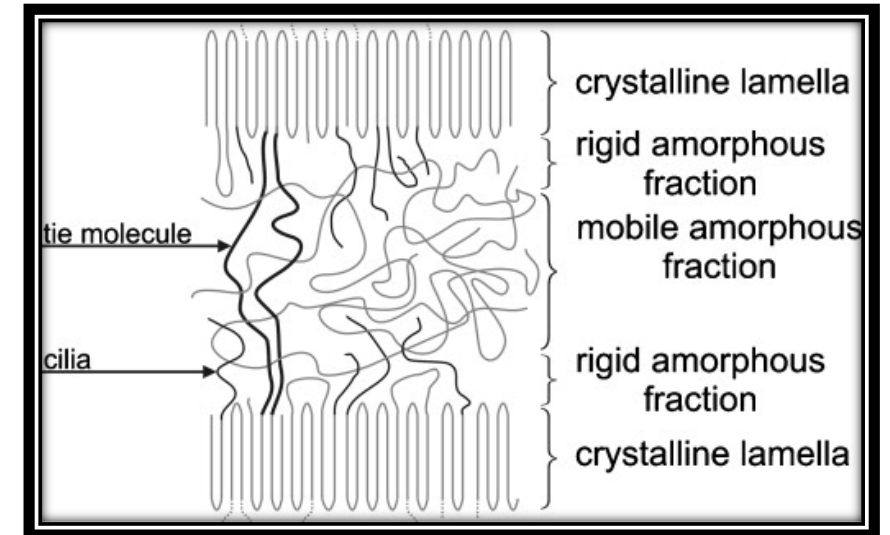
<https://pslc.ws/macrog/crystal.htm>

Fringed micelle model



[Influences of the Glassy and Rubbery States on the Thermal, Mechanical, and Structural Properties of Doughs and Baked Products](#), Slade and Levine, 1987

Lamella model



Wietzke, Steffen & Jansen, Christian & Reuter, Marco & Jung, Taekgeun & Hehl, Judith & Kraft, Dietmar & Chatterjee, Sangam & Greiner, Andreas & Koch, Martin. (2010). Thermomorphological study of the terahertz lattice modes in polyvinylidene fluoride and high-density polyethylene. Applied Physics Letters. 97. 022901 - 022901. 10.1063/1.3462312.

Effects of stress and stretching on fiber properties (orientation)

- alignment horizontally in the fiber axis
- The polymer chains get closer and glide
- Increased crystallinity
- Increased secondary interactions between polymer chains
- Decreased fiber denier
- Increased breaking strength
- Decreased elongation at break
- Observation of anisotropic behavior
- Increased lustre

Linear and branched polymer chains are held together by;

- A) London forces
- B) polar interactions
- C) H-bonds

These interactions observed between the molecules are called **van der Waals** forces or secondary forces.

Effects of H-bonding on the fiber properties:

<< the elongation ratio of the fiber decreases as a result of preventing the gliding polymer chains

<<< increases the elasticity of fibers due to having weak cross-link character.

<<< increase the moisture absorption ability of fiber

Molecular weight and chain shape

Linear polymer chains >>>> increases the crystallinity
branched polymer chains are not suitable for crystalline structure

The breaking of a fiber occurs via two different mechanisms.

- I) molecular degree << polymer chains are broken
- II) polymer chains are separated from each other by gliding

The length of polymer chains have a significant effect on the fiber breaking style.
Polymers with high molecular weights <<<< difficult breaking (more forces are needed to break the secondary interactions)

Linear symmetry

- This concept corresponds to the sequence of the side groups of a polymer chain in a different way.
- The polymers with linear symmetry tend to the ordered-packaging and thus, crystallinity.
- HDPE >>>>>> does not contain side groups, thus crystalline polymer
- LDPE >>>>>> contains branched polymer chains, less crystallinity.

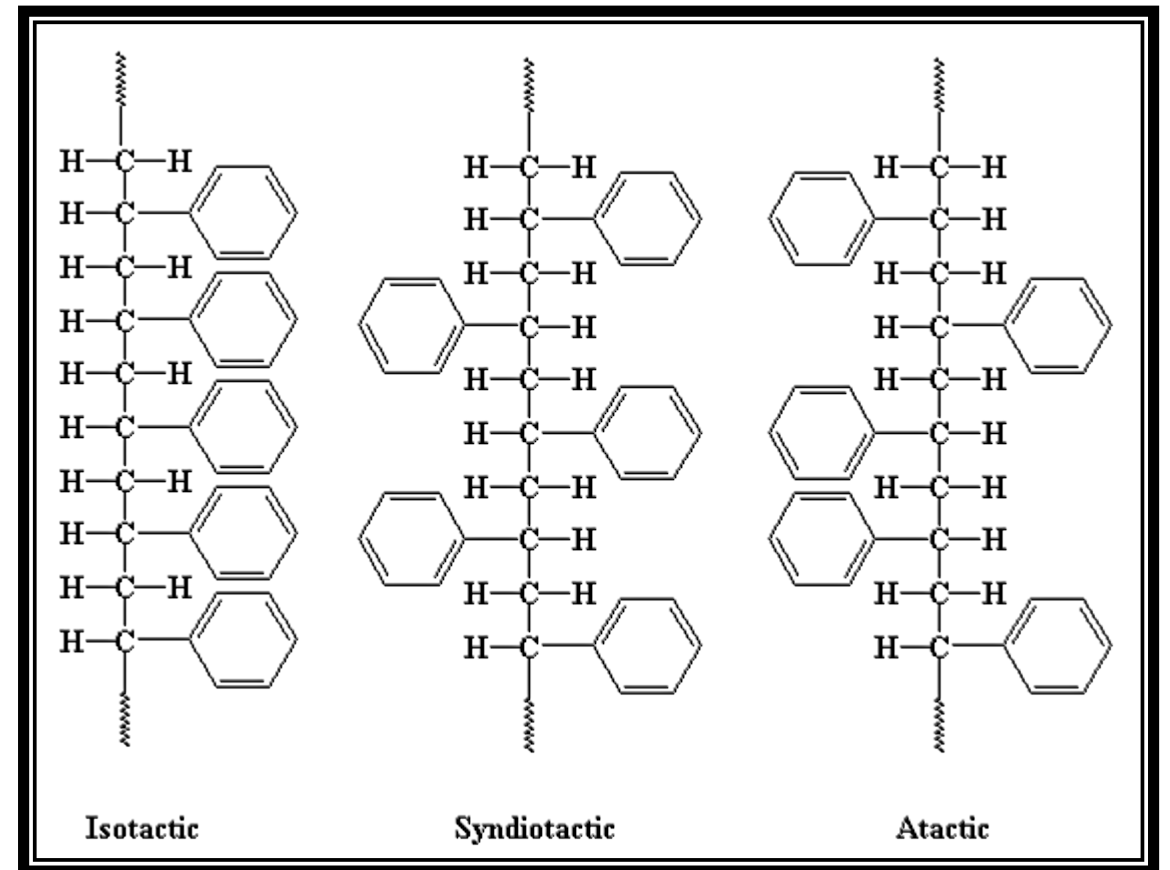
? Homework: which of the polymer is more prone to give a fiber form?

Why?

Tacticity

**sequence of the $-R$ groups of polymer chains consisting of $CH_2=CHR$ vinyl monomers

Syndiotactic and isotactic polymers are prone to the crystallinity due to their high arranged geometry.



Factors effecting cristallinity

- The units take part in the main polymeric backbone

++The simple and symmetric units containing polymers such as PE, PTFE tend to cristallinity. The other groups such as $-\text{CO}-$, $-\text{COO}-$, $-\text{CONH}-$ are also prone to the cristallinity.

- The tacticity of the polymer chain

++syndiotactic and isotactic polymers are prone to the cristallinity.

- Branching

--Adversely affects the cristallinity

- The interactions between polymer chains

++The secondary forces such as H-bonds, polar interactions get closer the polymer chains and this leads to the orderly arrangement of the polymer chains.

? Homework: show the H-bonds and polar interactions in the Nylon 6-6 and polyacrylonitrile, respectively.

Molecular flexibility

- Molecular flexibility (chain flexibility) is the concept defining the rotating ability of polymer chains around the bonds in the main polymer chains. (in the other words, the rotating ability of polymer chain around σ bonds)
- The side groups effect the molecular flexibility. The side groups also have significant effects on polymer solubility, glass transition temperature, and crystallinity ability.
- Molecular flexibility also depends on the main groups present on the main polymer chain. E.g $-\text{O}-\text{C}-$, $-\text{COO}-$, $-\text{OCOO}-$ groups increase the molecular flexibility.
- The molecular flexibility of the polymer chains are adversely effected by the presence of p-phenylene groups in the polymer. These groups also increase the melting temperature of the polymer.

? Homework: write some examples for the polymers containing p-phenylene groups. Compare the T_m value of p-phenylene and $-\text{CH}_2-$ groups containing two polyester polymers.