

In-Class Exercise Crystalline Polymers SOLUTIONS

1. List things in polymers we have discussed that influence the mechanical properties of polymers. Explain what effect these factors have.

In terms of mechanical properties of polymers, we are concerned with the modulus of elasticity (this is a measurement of how well a polymer stretches in the elastic region due to bonds in the chains stretching), the tensile strength (the stress of the material at failure), and ductility (% elongation, the % strain at failure). In general, polymers that have a larger tensile stress (can support a greater stress before failing) have less ductility. This is because it is harder to untangle the chains.

Some things we have talked about in the polymer classification that affect the mechanical properties are:

Size making it hard for chains to untangle

- Molecular weight: Higher molecular weight (from either bulky monomers or longer chains) are harder to untangle, giving a higher tensile stress and lower ductility. That is, it takes more applied force to untangle them and get them to eventually fail.
- Bulky side groups: Monomers with bulky side groups have a higher TS and lower ductility because the side groups prevent chains from sliding past one another.

Increasing chain interaction to increase TS

- Linear vs Branched: linear polymers have a higher TS and lower ductility. The chains pack in denser and have more interchain interactions, this secondary bonding makes it harder for chains to untangle.
- Crosslinking increases connections between chains, lowering ductility and increasing TS. Networking provides even stronger connections between chains, having an even greater effect on the mechanical properties.
- Cis vs trans geometrical isomerisms: In trans geometrical isomerisms the sidegroups are on opposite sides of the double bond in the chain. This creates kinks in the chains that prevent the chains from packing in close. This results in the TS of trans being less than cis (due to less chain to chain interaction).
- In isotactic stereoisomerism, all the sidegroups are on the same side. This allows the chains to pack in tighter and have more interaction (increasing TS and lowering ductility).

2. List factors that influence the percent crystallinity in a polymer.

The crystallinity is increased when the chains can pack in tighter. Things that lower the crystallinity (make it harder for chains to pack in tighter) are:

- Bulky sidegroups
- More complex monomers
- branching
- amorphous tacticity (isotactic stereoisomerism is more crystalline)