Lecture 25, Mar 24, 2022

Molecular Weight in Polymers

- The main part of strengthening polymers involves making it harder for polymer chains to slide past each other
- Molecular weight: the size of each macromolecule
  - The longer the molecules (higher molecular weight), the more they will get tangled and so the polymer will become stronger
    * e.g. UHMWPE
- Not all molecules are the same weight, so several methods are used to describe the distribution:
  - Number average: $\bar{M}_n = \sum_i x_i M_i$
    * Broken into "bins" of mass/length ranges
    * x_i is the *number fraction*, the fraction of molecules that are in that bin
    * M_i is the mass of each molecule in that bin
    * Exactly like a normal weighted average
  - Weight average: $\bar{M}_w = \sum_i w_i M_i$
    * w_i is the *weight fraction*, $w_i = \dfrac{N_i M_i}{\sum_j N_j M_j}$
      - i.e. w_i is the total weight molecules in that bin divided by the total weight of all molecules
    * Bins with higher molecular weight are weighted more in the average
  - The weight average is always greater than the number average (except the hypothetical case where all chains are the same length)
  - $Đ = \dfrac{\bar{M}_w}{\bar{M}_n}$ ("D stroke") is the *dispersivity* or *polydispersivity index* and measures spread (width of distribution)
    * This number is greater than 1; the greater the dispersivity, the more wide the spread of molecular weights
    * Đ for isotatic commodity grade (i.e. cheap) polypropylene is about 3.5 (i.e. a very wide distribution)

Crystallinity of Polymers

- Sometimes polymers can fold into regular patterns and crystallize
  - It's impossible for the entire polymer to crystallize
  - There are crystallized regions with amorphous regions in between
- More crystallization implies higher density
- Since the chains are folded tightly, the intermolecular bonds are stronger so the polymer has higher strength, wear resistance, and higher resistance to chemicals