Lecture 24, Mar 21, 2022

Structure of Polymers

- Toughness: How much energy a material can absorb before it breaks
  - The area under a stress strain curve has a unit of $\mathrm{N/m^2}$ or $\mathrm{N\,m/m^3}$, or energy per volume
- Polymers are long chains of molecules
- Simplest polymer: polyethylene (PE)
  - Note polymers are named from the starting molecule
- The long molecule chains get tangled in a polymer and are loosely connected together; both intramolecular forces and intermolecular forces are at play
  - A polymer's strength is dependent on how easily the molecule chains slide past each other
- For a polymer, the yield strength is defined as the first peak of the curve; the tensile strength is the stress at which it breaks
- Some common polymers:
  - Polyethylene (PE): 2 carbons, every carbon has only 2 hydrogen
    - Has many varieties, e.g. high-density polyethylene (HDPE), low-density polyethylene (LDPE), ultra-high molecular weight polyethylene (UHMWPE, Dyneema)
  - Polypropylene (PP): 2 carbons, one carbon has 2 hydrogens, the other has 1 hydrogen and a methyl (CH_3) group
    - Used in plastic bags
  - Polyvinyl chloride (PVC): 2 carbons, one with 2 hydrogens, one with 1 hydrogen and 1 chlorine
    - Used in pipes
    - Typically stiff, but plasticizers can be added to make it flexible
  - Polytetrafluoroethlene (PTFE): Like PE but with fluorine instead of hydrogen
    - Also known as Teflon
    - Carbon-fluorine bond is strong so this material is very inert
  - Polymethylmethacrylate (PMMA): 2 carbons, one with 2 hydrogens, the other with a methyl group and (carbon with double bonded oxygen, and single bonded oxygen with methyl group)
    - Also known as acrylic
    - Glasses are made of this
    - The big side chain prevents the chains from stacking next to each other
- Putting a polymer under tension lines up the molecules in a single direction
  - This increases the tensile strength since more of the load is now carried by stronger intramolecular bonds rather than intermolecular bonds
  - Pulling it in the other direction afterwards is much easier to do, since the chains are now aligned in the wrong direction
  - Also changes optical properties (e.g. makes the plastic white)