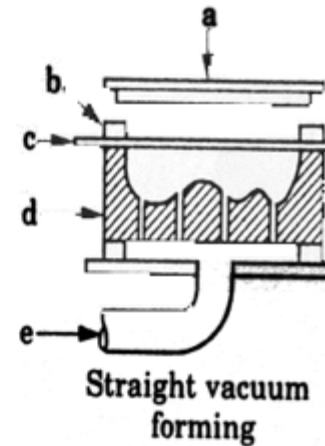
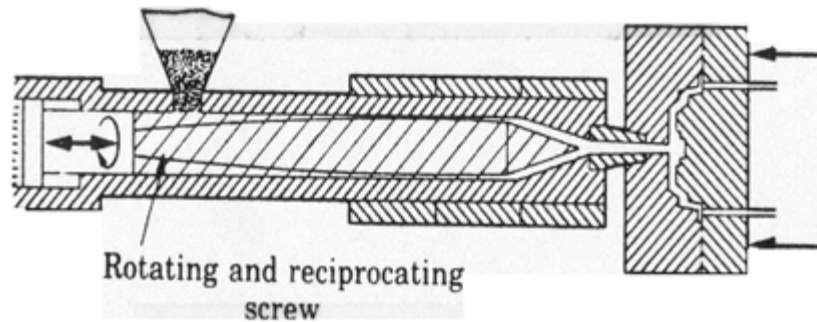


Today: Plastics processing



Cost: 👍
Expensive \$100.00 — \$10,000.00

Flexibility: ~~
Dies need to be prepared.

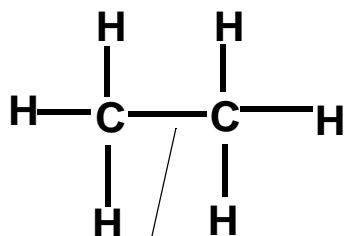
Quality: ~~
Very high quality.

Rate: 👍
Very fast. Several

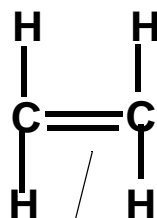
Outline

- Polymers: a mini-lecture
- Injection molding equipment, process, tooling
- Rate issues and parameter selection
- DFM

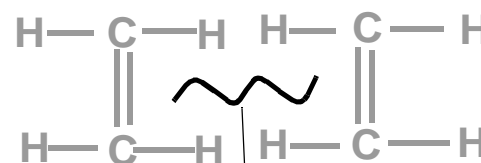
Hydrocarbon basics



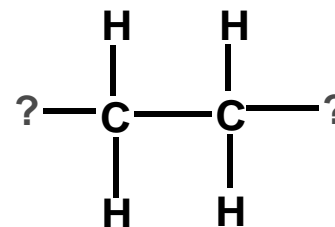
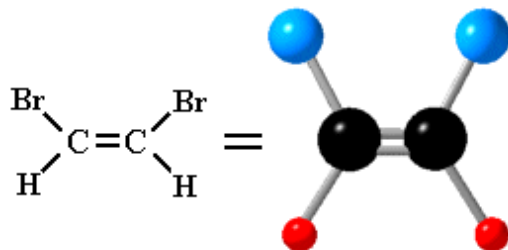
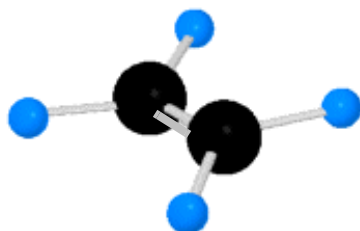
Covalent bond



Double bond

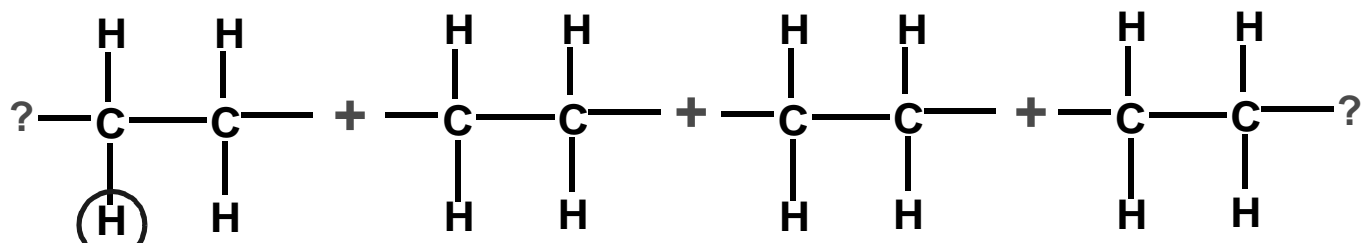


Weak Vanderwaals force

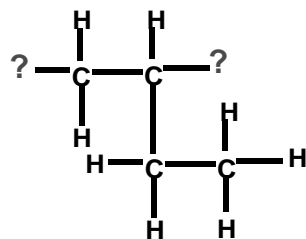
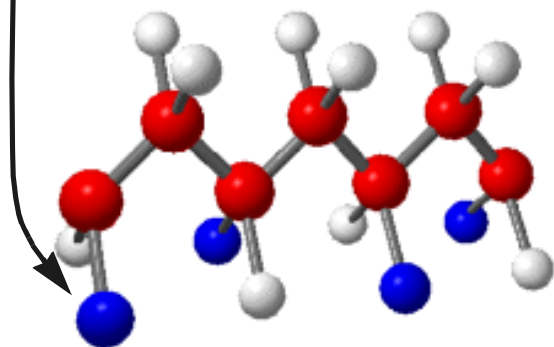


Ethylene *monomer*

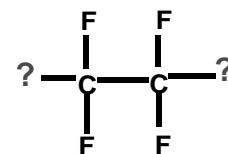
Polymers



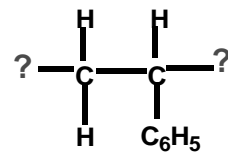
Bromine?
Chlorine?



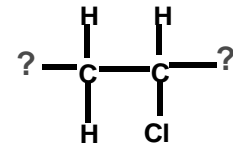
Polypropylene



Teflon
(PolyTetrafluoroethane)

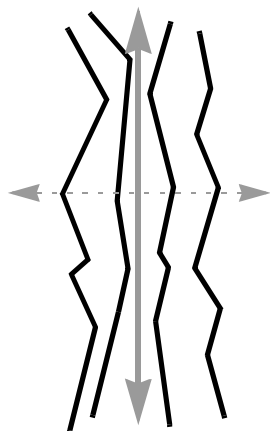


Polystyrene

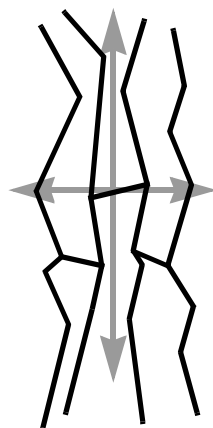


PolysVinylChloride

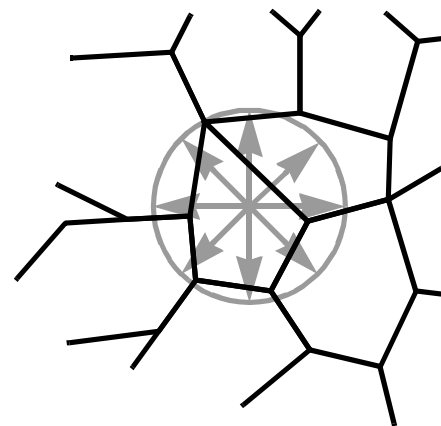
Structure



Linear

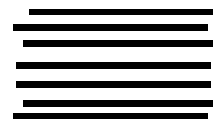


Cross-linked chain



Branched

- Linear polymers are usually *thermoplastics*. Their strength is direction dependent.
- Cross-linked polymers are usually *thermosets*. The links set the polymer.

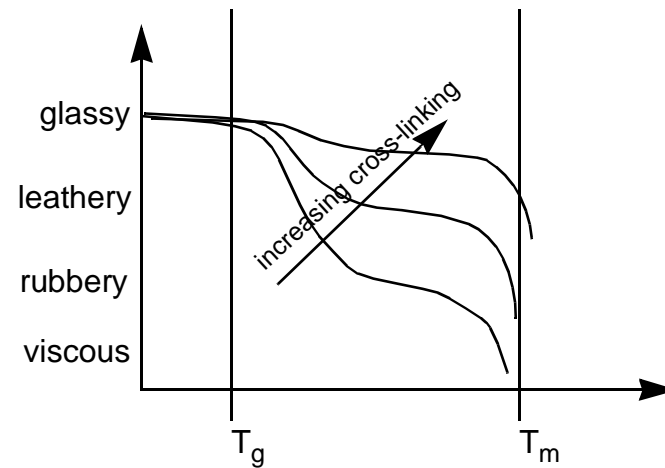
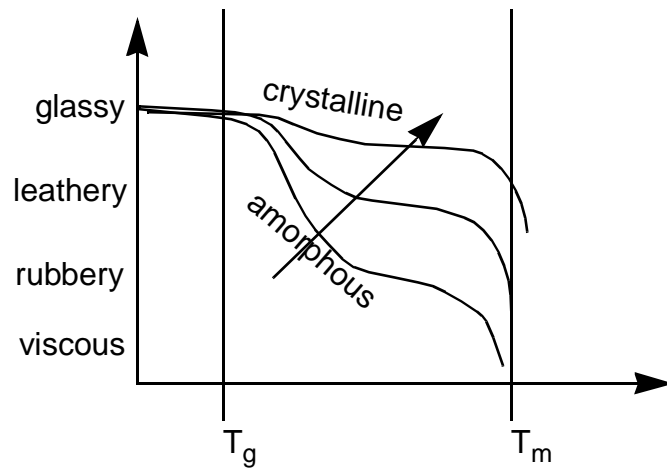
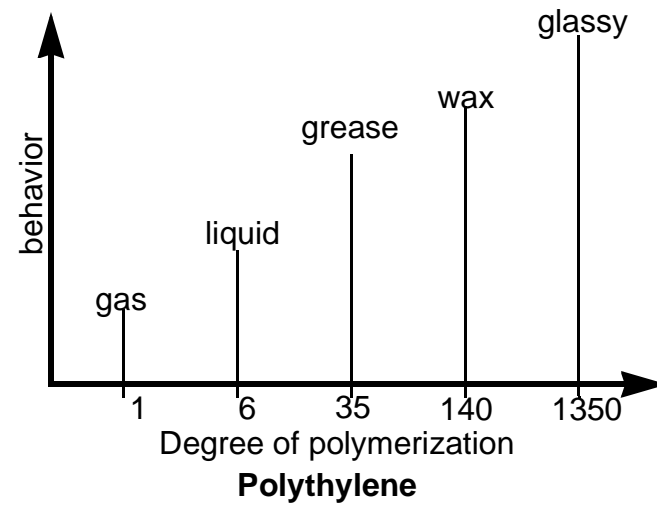
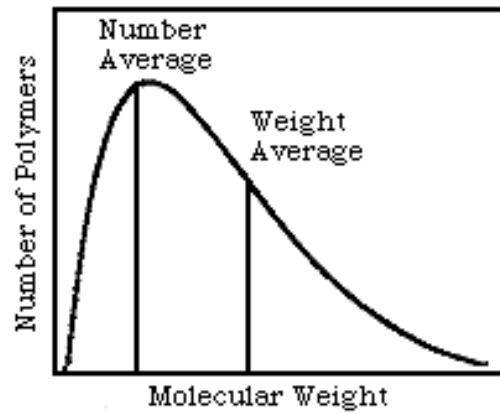


Crystalline



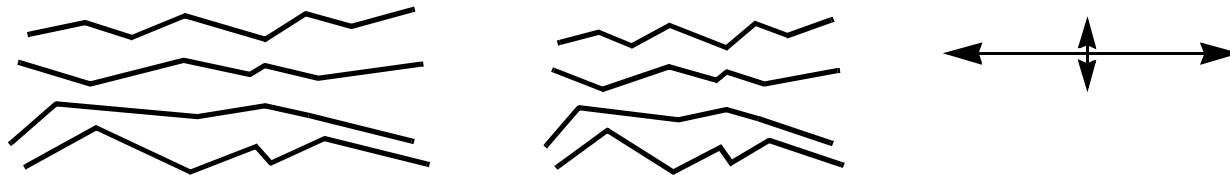
Amorphous

Polymers behavior



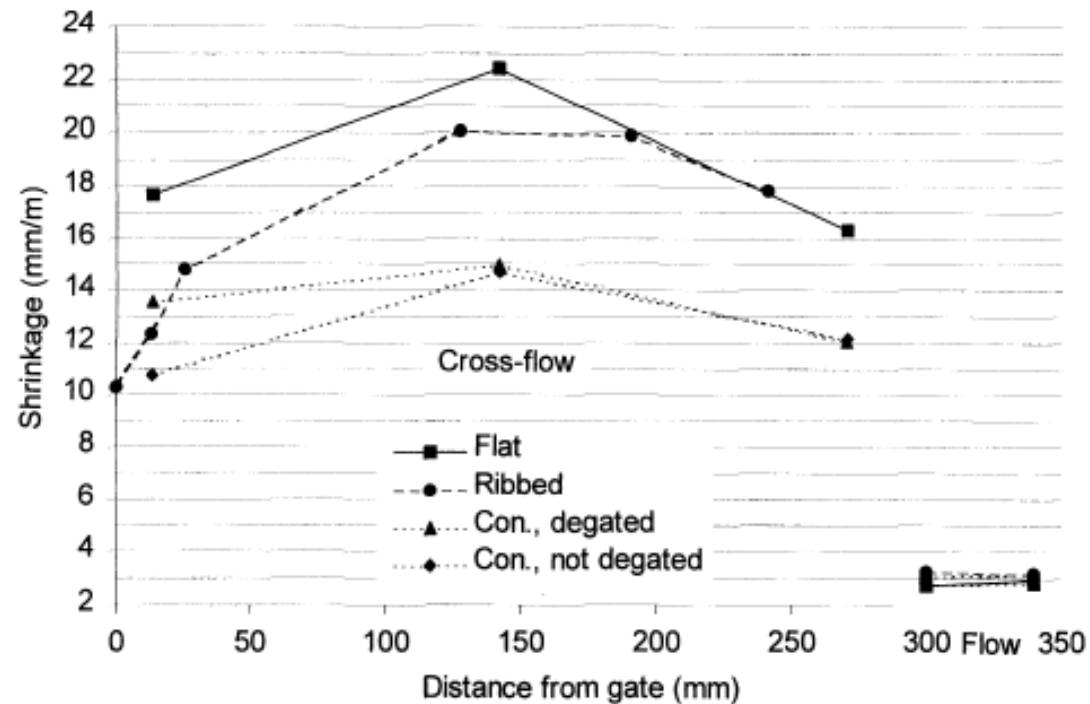
Phase change and Shrinkage

- At very high temperatures, thermoplastic polymers degrade and thermosets char.
- Polymers shrink substantially when they *solidify* and *cool*
- The slower the solidification rate, the lower the residual stresses
- For linear polymers, the shrinkage is direction dependent



from http://isl.cps.msu.edu/trp/inj/dim_cons.html

EXPERIMENTAL SHRINKAGES: GLASS-FILLED PA (ZYTEL 70G33L)



[illegible]

Polymer examples:

- Thermoplastics: Acrylics, cellulose, nylons, polythylenes, PVC's, polymethylmethacrylate (PMMA), etc.
- Thermosets: Epoxies, resins, glues (eg, handles of cooking vessels)
- Branched polymers: Phenolics
- Note that $E_{\text{polymers}} \sim 0.01 E_{\text{metals}}$
- Note that crystalline polymers tend to be harder and more corrosion/temp resistant than amorphous, and thermosets more so than thermoplastics