MSE250 – Comments on Homework 9

Updated 23 November, 2011

Comparing thermoplasts, thermosets, and elastomers (Question 2):

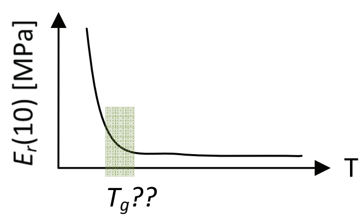
- "molecular structure" includes chain arrangements (crystallinity, coiling), not just chain structure
- "bonding types": crosslinks are covalent too, just like the bonds within a chain
- "mechanical properties": does not refer to the interchain motion/mobility, although this is a good microscopic explanation for polymers' mechanical properties: **stiffness** (E, rigidity, elasticity), **strength** (σ_y), **ductility** (brittleness, capacity for plastic deformation), and **viscosity**; you must also consider the **effect of temperature** (e.g. racketball) on these properties

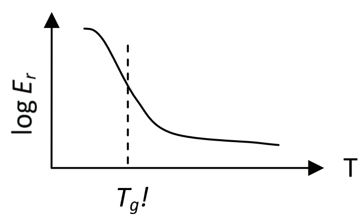
Propensity for crystallization (Question 5):

- I would like to clarify that even though in discussion, we wrote that "no crosslinking" is better for crystallization, ***small*** **amounts of crosslinking (part b) would still allow a polymer to crystallize** – just not to the extent that a completely crosslink-free polymer could
- I would like to clarify that **graft and random copolymers will never crystallize**; I do not think I emphasized this in discussion. This automatically eliminates one of the polymers in part d)

Relaxation modulus, $E_r(10)$, versus temperature (Question 6, #15.7)

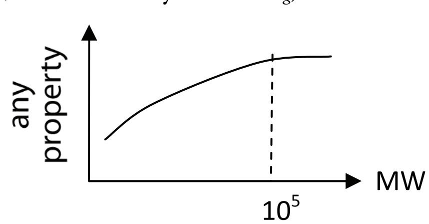
- Because the question asked you to plot "$E_r(10)$ versus temperature", I did not take points off if you did just that. You should note, though, that **logE_r(10) vs. T is a better plot**, due to the drastic drop in modulus with increasing temperature. It is then *much* easier to pick off the inflection point, and get your T_g





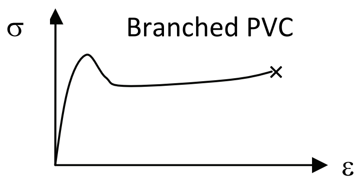
Factors affecting thermoplastic polymer strength (Question 7, #15.15)

- this question was modified to 15.15 from 15.14; about ten people disregarded this change!!
- 15.14 asked about factors that affected the modulus of thermoplastic polymers (different from strength; "slope, not endpoint"). It would be good for everyone to know that **the textbook is incorrect in saying that molecular weight has no effect on the modulus**. In class, Dr. Wynarsky specifically stated that *any* property (well… at least strength, stiffness, hardness, and viscosity above T_g) has this kind of relationship with molecular weight:

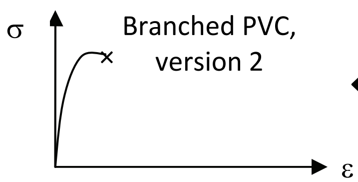


Stress-strain behavior comparison (Question 8, #15.22)

- In part b (comparing branched PVC and heavily crosslinked PVC), most people drew the latter curve correctly, as a straight, high-sloped line (stiff and brittle). However, branched PVC is an ambiguous case. Many people drew the following for branched PVC:



We will accept this answer because there was no mention (except in Question 10) of the T_g of PVC (~50-80°C), nor of the temperature at which we are comparing the two polymers in part b. If we assume room temperature (< T_g), branched PVC would *not* exhibit such ductile behavior as shown on the left. It would look more like the one below:



⬅ This would be more correct, as PVC is actually quite a stiff polymer at room temperature; that's why it's used in piping!

Polymer behavior (Question 9)

- **There are two ways to use the terms "thermoplast", "thermoset", and "elastomer"**: one describes the molecular structure/class of a polymer; the second describes the typical mechanical behavior of the above structures:
  - Thermoplast: elastic (low E), low strength, high ductility (plastic)
  - Thermoset: rigid/stiff (high E), strong, brittle
  - Elastomer: very elastic (very low E), low strength

  This being said, an elastomer will <u>behave</u> like a thermoset below T_g, even though its structure is still that of an elastomer (long coiled chains with crosslinking)

- In part e, we encounter PVC again. We accepted both "thermoplast" and "thermoset" as correct answers for this question because T_g was not given (again…). The description of the polymer as being "linear" and "amorphous" indicates thermoplast structure. However, <u>when talking about behavior</u>, we must consider temperature effects: T_g of PVC is 50-80°C; thus, technically, at 25°C, we would have thermoset behavior. *However*, this was not given in the problem, and also, room temperature is not *that* far below T_g (there is a *range* over which the modulus changes – see Question 6 or Fig. 15.7 in the 8th edition), so there *could* still be some thermoplastic behavior. Isn't ambiguity awesome?