MSE 214 (Polymers)
Exercise 5 — Microstructure and Properties
29th October 2025

Question 1.

The glass transition temperature of pure Nylon 6,6 is 50˚C. How much plasticizer do we need to add to a film of Nylon 6,6 for the T_g of the homogenous blend to be 25˚C? The T_g of the plasticizer is -80˚C. Please give your answer in weight percent.

Question 2.

A polymer is immersed in a solvent.

a) Describe what happens to the polymer if it is linear and the solvent is a good solvent. What will the solution look like?

b) Describe what happens to the polymer if it is crosslinked and the solvent is a good solvent. What will the solution look like?

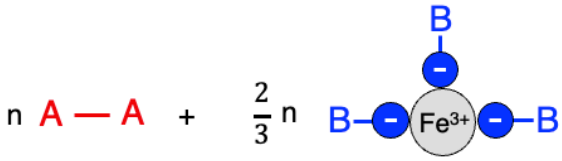
c) Describe what happens to the polymer if it is linear and the solvent is a poor solvent. Assume the solvent is very cold. What will the solution look like?

d) For situation c), what happens the polymer if we slowly heat the poor solvent. Assume no boiling of the solvent or degradation of the polymer. What will the solution look like?

Question 3.

a) What are the three main differences between chemical and physical crosslinks?

b) Consider the two monomers below that can participate in step growth polymerization (A+B→AB):



The trifunctional B type monomer is comprised of an Fe^{3+} metal ion that is electrostatically interacting with three negatively charged monofunctional B functional groups.

i) Will these two monomers result in a crosslinked or linear polymer?

ii) What kind of crosslinks exist in this polymer (if any)?

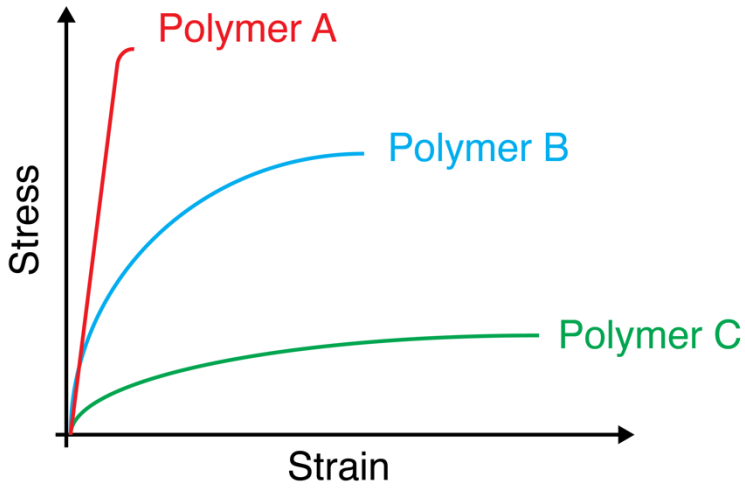
c) The T_g of a polymer increases as the degree of crosslinking increases. Why?

d) It was mentioned in class that all polymers have a glass transition temperature. However, this is sometimes not observed in highly crosslinked polymers. Why?

Hint: Look at the slide on “General Polymer Properties — Low Thermal Stability”

Question 4.

You have three semi-crystalline polymers: A, B, and C. They were all cooled from the melt, but at different rates. They were then subjected to tensile testing at a temperature that was above T_g but below T_m. Using the stress-strain curves shown below, answer the following questions:



i) Which polymer is the most brittle? Why?

ii) Which polymer is the toughest? Why?

iii) Rank the polymers from fastest cooling rate to slowest cooling rate. Explain your decision.

Question 5.

During injection molding of semi-crystalline polymers, the temperature of the mold is very important. If the mold temperature is too low, the polymer parts made can have inhomogeneous mechanical properties — the surface of the polymer parts have poorer mechanical properties than the bulk. Why do you think this happens?

Hint: What happens if you have a hot polymer liquid contacting a cold or hot mold? Compare the rate of cooling in both cases.

Question 6.

Polyacrylonitrile (PAN) is a major precursor for high-strength carbon fibers. It is a solid. In industry, PAN is first dissolved in a solvent such as dimethylformamide (DMF) or dimethyl sulfoxide (DMSO) to form a viscous polymer solution. This solution is then extruded through a spinneret into a coagulation bath (often water or another nonsolvent) to form fibers — a process known as solution (wet) spinning.

a) Describe what happens to the polymer chains as they move from the good solvent spinning solution into the nonsolvent coagulation bath.

b) Heat processing is generally more economical than solvent processing due to the challenges with solvent handling and recovery. Why do you think PAN is solvent processed instead of heat processed (as we described in class for extrusion processes)?