

080610 Final: Introduction to Polymer Science (Chemistry)

Final First Quiz New Material

Last week Ram did two demonstrations of emulsion polymerization and suspension polymerization and we discussed anionic, cationic and ATRP methods for living polymerization.

- 1)
  - a) Describe the monomer and majority phase liquid ('solvent') used in the emulsion polymerization.
  - b) According to Wikipedia the term "surfactant" was first used by Antara Products in 1950. A more general term for a surfactant is an amphiphilic molecule which means a molecule with a hydrophobic group (tail) and a hydrophilic group (head). Describe the surfactant used in the emulsion polymerization.
  - c) What initiator could be used for this polymerization.
  - d) Is the initiator miscible in the non-solvent phase? Explain why.
  - e) How is the polymer separated from the reactants, surfactant and non-solvent?
  
- 2)
  - a) Describe the monomer, majority phase liquid and initiator used in the suspension polymerization.
  - b) Why was this initiator chosen?
  - c) Under what conditions does this initiator produce free radicals?
  - d) The polymerization done by Ram in class failed to produce polymer. Speculate on why this reaction didn't work. (Consider what is needed for the initiation, and propagation steps of this reaction.)
  - e) What advantages do emulsion polymerizations have over suspension polymerizations?
  
- 3) For an ideal polymerization reaction termination would not exist and the polymerization reaction would result in a single molecular weight product if all chains were simultaneously initiated.
  - a) List two methods by which ideal, living polymerization conditions can be achieved.
  - b) In class we watched a video of a living anionic polymerization. Describe the monomer, initiator, solvent and special conditions needed for such a polymerization.
  - c) What characteristic does the monomer need to be able to be polymerized anionically?
  - d) Show the characteristic of question c for the monomer in this reaction.
  - e) What does ATRP stand for?

## Final Second Quiz from Quiz 1, 2 and 3

Q1-1) The flow of polymer melts and concentrated polymer solutions display features that are distinct from low molecular weight materials.

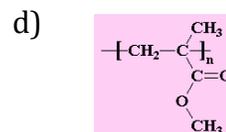
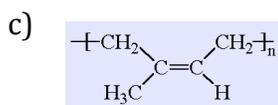
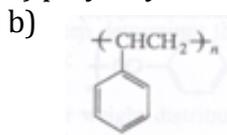
- a) Sketch a plot of log of shear viscosity versus log of molecular weight showing shear thinning behavior for a polymer.
- b) Sketch a plot of log of the viscosity at low shear rate (from part "a" for instance) versus log of the molecular weight for oligomers and polymers indicating the transition from oligomer to polymer.
- c) Give an example of the first normal stress difference observed in polymer flow (that is stress generated at a right angle to the direction of flow).
- d) Give a short explanation based on the structure of a polymer melt that can explain the observed behavior in parts a, b and c.
- e) At higher temperatures polymers under shear act as if they were subjected to a lower shear rate, that is, they behave more Newtonian at higher temperatures. Explain why you think high temperatures would be associated with a reduction in the feature you describe in part d.

Q2-1) Low molecular weight materials display a single value for the molar mass but synthetic polymers display a spectrum of molar mass.

- a) Why do you think a single molecular weight isn't seen for polymers (we didn't go through this in class so just guess from what you know and thinking of the mechanisms of initiation of growth, growth and termination of growth for a polymer chain). You may want to describe the conditions that could lead to a monodisperse polymer (PDI = 1) in answering this question.
- b) Describe the difference between a unimodal molecular weight distribution and a bimodal or multimodal distribution. Why might a bimodal distribution be seen in polyethylene?
- c) Other than GPC name two methods that could be used to measure the molecular weight of a polymer and what moments of the molecular weight distribution they measure.

Q3-2) Draw the structure or give the name of the following polymers and indicate which of the two types of polymerization could be responsible for this polymer. Indicate, where appropriate, the polyester, polyamide or polyurethane linkages.

a) polyethylene terephthalate



e) Poly vinyl alcohol

### Final Third Quiz from Quiz 4 and 7

Q4-1) In class we synthesized nylon using a Schotten-Baumann interfacial polymerization method. According to wikipedia:

*The name "Schotten-Baumann reaction conditions" is often used to indicate the use of a two-phase solvent system, consisting of water and an organic solvent. The base within the water phase neutralizes the acid, generated in the reaction, while the starting materials and product remain in the organic phase...*

- a) How does the nylon synthesis used in class reflect Schotten-Baumann conditions?
  - Give details of the organic solvent and base that are used and specify what acid is neutralized.
  - Does the product remain in the organic phase?
  - Do the the starting materials remain in the organic phase?
- b) Give an advantage and a disadvantage for the interfacial reaction used to make nylon compared to the glyptal reaction.
- c) What determines the rate of reaction in an interfacial reaction? (e.g. concentration, reaction rate constants, transport, byproduct or product removal etc.)

Q4-2) We also synthesized glyptal polyester in class which has some similarities to the condensation synthesis of polyethylene terephthalate (PET or PETE, i.e. water bottles).

- a) Why is phthalic anhydride used rather than phthalic acid in the glyptal synthesis?
- b) Give two reactions that phthalic anhydride undergoes in the polymerization and 3 ways that it can be incorporated into the growing polyester chain.
- c) Give two reactions that sodium acetate can undergo in this reaction.

Q7-1) We made polyacrylamide by concentrated solution (similar to bulk) and by solution polymerization.

- a) Give the chemical structure of the monomer and explain why it is soluble in the solvent used.
- b) What initiator can be used to polymerize this monomer and under what conditions?
- c) Compare the extent of reaction "*p*" that is needed to make a high molecular weight polymer for this chain growth polymerization compared to that needed for high molecular weight in a step growth polymerization.
- d) How was the polymer separated from the reaction solution? (Why was a small amount of HCl used?)
- e) Compare the reaction when the monomer concentration was very high to the reaction when the monomer concentration was moderate in terms of scale-up to an industrial synthesis (consider heat, ability to separate polymer and waste solvent byproduct).