

## CME 300 Properties of Materials

### Homework 8 November 17, 2011

Repeat Problems from Homework 6: 9), 10), 14-12) and from Homework 7: 11), 12), 13), and 14) and do the following 7 problems.

- 1) Describe the molecular difference, difference in synthesis method and different uses for high density polyethylene, low density polyethylene, linear low density polyethylene, metallocene polyethylene, compression molded ultra-high molecular weight polyethylene, gel spun ultrahigh molecular weight polyethylene (Google the latter two).
- 2) Which termination routes for polyethylene can lead to branching? Show a reaction scheme for these routes including the branching reaction. Do you expect polypropylene to show these kinds of branching reactions? Why?
- 3) Ferrocene is the least expensive and prototypical metallocene molecule consisting of two cyclopentane rings and a  $\text{Fe}^{+2}$  iron ion. In 1973 Fischer and Wilkinson shared a Nobel Prize for their work elucidating the structure of Ferrocene and for development of other metallocene molecules. In the late 1990s and early 21'st century Dow Chemical, ExxonMobil and Dupont competed to develop polyolefin catalysts based on metallocenes that lead to the current metallocene catalyst systems in industrial use. Ferrocene is so inexpensive that is used as a diesel fuel additive to reduced soot emissions and can be used in the synthesis of carbon nanotubes, in both cases taking advantage of the organo-solubility of this iron salt. Describe how you think ferrocene might be useful in these two cases, i.e. a) how does it lead to degradation of soot and b) how could it be useful in the synthesis of nanotubes?
- 4) Why is it impossible to synthesize polypropylene by free radical polymerization?
- 5) The Gaussian distribution is described by a mean value and a standard deviation. The mean is given by  $\frac{\int MP(M)dM}{\int P(M)dM}$  where  $P(M)$  is the number distribution of chains as a function of molecular weight,  $M$ . The standard deviation is defined as  $\sqrt{\frac{\int P(M)(M - \text{mean})^2 dM}{\int P(M)dM}}$ . Define the number average, weight average, z average and the polydispersity index in terms of the mean and standard deviation from the Gaussian distribution.
- 6) Metals are processed in the melt and cast in molds. This metal can later be rolled, drawn and annealed to form various parts. Polymers are generally processed in an extruder. Sketch an extruder showing where pellets are fed in, melting occurs, pressure is built up and extrusion occurs. Why aren't polymers processed like metals? What is the most

important material property for polymer processing? How do injection molding, film blowing, film casting and wire coating rely on an extruder?

7) What is a band gap and why is it important to semi-conducting materials.