

## MSE 521 - Properties of Solid Polymers

### Problem Set 4

Due: Tuesday, Nov. 28, 2000

### Thermodynamics of Polymer Blends

1) Polymer blends are to be made from a poly(butadiene) (h-PB) of weight average molecular weight  $M_w = 154,000$ ,  $M_w/M_n = 1.01$  and a perdeuterated-polybutadiene (d-PB),  $M_w = 171,100$ ,  $M_w/M_n = 1.01$ . The d-PB is the same in all respect as the h-PB except that the d-PB has all hydrogens exchanged for deuterium. The Flory parameter,  $\chi$ , for the d-PB/h-PB pair is given by:

$$\chi = (0.326/T) - 2.3 \times 10^{-4}$$

where T is the absolute temperature (K). Compute and plot the following:

- (a) The normalized free energy of mixing  $G_{\text{mix}}/Nk_B T$  versus  $\phi_{\text{d-PB}}$  at the following temperatures: 300K, 350K, and 400K.
  - (b) Compute the binodal and spinodal  $\phi$ 's for a range of temperatures and use these to compute and plot the phase diagram for this system.
  - (c) What would be the degree of polymerization (where both d-PB and h-PB have the same degree of polymerization) for the critical point of the system to be at 0° C?
  - (d) Suppose a sample of the original blend with  $\phi_{\text{d-PB}} = 0.5$  is quenched from 100 to 0° C. What will happen and what is the magnitude of the thermodynamic driving force causing this to happen (in units of  $Nk_B T$ )?
- 2.) Identify a polymer that is miscible with polystyrene. Polystyrene (PS) and the second polymer (e.g. poly(xylynyl ether) PXE, (repeat formula =  $C_8H_8O$ ) or poly(vinyl methyl ether) PVME, (repeat formula =  $C_3H_6O$ )) are miscible over a certain range of T. Assume the Flory parameter of the blend is independent of composition and is given by  $\chi = B - A/T$ . Select a polymer, find a temperature dependent value for  $\chi$ , then compute and plot the phase diagram of a PS-polymer blend where  $M_{\text{PS}} = 300,000$  and  $M_{\text{other}} = 50,000$ .

If you cannot find a value of  $\chi$ , ask me and I will select a system.