10.302
Fall 2004
Discussion Problem for Recitation on
Tuesday, November 30, 2004

Long polymeric cylinders with a radius of 2 mm have been produced in the laboratory with the intent of using them as part of an implantable biomedical device. Unfortunately, the rods contain a small amount of monomeric residue which must be extracted prior to use. In order to achieve this, the rods will be immersed in a large volume of well-stirred solvent. You have been asked to estimate the time required to achieve a ten-fold reduction in the monomer concentration at the centerline of the cylinders. The diffusivity of the monomer within the polymer is 10^{-6} cm^2/s, and the mass transfer coefficient between the surface of the rods and the solvent is 10^{-3} cm/s. Two solvents are under consideration and the solubilities of the monomer in the two solvents are known to be quite different. Specifically, the equilibrium partitioning of the monomer between the solvent and the polymer is given by:

Solvent A: $[C_M]_A = [C_M]_P$

Solvent B: $[C_M]_B = 0.05[C_M]_P$

where:

$[C_M]$ is the monomer concentration
A refers to solvent A
B refers to solvent B
P refers to polymer

a) What is the Biot number associated with the use of solvent A?
b) What is the Biot number associated with the use of solvent B?
c) If solvent A is used, how many hours will be required to achieve a 10-fold reduction in the centerline concentration?
d) If solvent B is used, how many hours will be required to achieve a 10-fold reduction in the centerline concentration?