ChBE/CHEM/MSE 6751 Physical Chemistry of Polymer Solutions (3-0-3)

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Prerequisites: Physical Chemistry and an introductory course in Polymer Science and Engineering at the level of ChBE/CHEM/MSE 4775, or Consent of the School and the instructor

Recommended Text: "Polymer Physics" by M. Rubinstein and R. Colby, Oxford, 2003. Publications from literature and other resources will also be used.

Course Outline

- Introduction and review of relevant Physical Chemistry
- Ideal and real chain statistics
- Thermodynamics of mixing
- Polymer solutions
- Polymer blends
- Polymer Dynamics
- Viscosity, light and neutron scattering, colligative properties
- Theories of viscosity and diffusion
- Scaling laws

Detailed Course Content

- A Generic introduction to polymer science
- Dimensions of polymer chains – ideal and real chain statistics
- Determination of chain dimensions – scattering, fluctuations, osmotic pressure, and analogy to ideal gas laws
- Scaling Concepts in Polymer Solutions
- Mixing of Polymers – phase behavior – Flory-Huggins Theory
- Modes of Phase separation – nucleation and growth, Spinodal decomposition
- Block Copolymers and Phase Separation
- Rods in Solution and Liquid Crystalline phases
- Frictional Properties of polymers in solution (Rouse and Zimm models)
- Dynamics of Polymer Chains (motion in un-entangled and entangled chains)

Topics to be covered include but not limited to the following:

- Polymers, their macroscopic properties, and the importance of understanding polymer behavior in solution.
- What are the chain characteristics? Size of polymer chains, different models for chain conformation and why an understanding of the chain conformation is important in dealing with polymers either in the melt or in solution.
- How do polymers behave in solution? What properties change with the addition of polymers to a solvent? Included in this are Osmotic Pressure, light scattering and the connection between the two – scattered intensity and osmotic pressure – analogy to ideal gas laws, molecular weight determination using light scattering, viscosity, and osmotic pressure, among other things.
- What is the phase diagram of a polymer in solution? Included in this are things dealing with entropy of mixing, lattice model, and the derivation of Flory-Huggins expression for the free energy of polymers in solution, and calculation of phase boundaries – modes of phase separation and how does one interrogate phase separation?
- How do the properties change when the polymer added to a solvent has a rod-like nature as opposed to random chain conformation? Viscosity, phase behavior and formation of ordered phases will be included in the discussion.
- How do polymer chains move in melt or in solution? Theories of viscosity, dependence of viscosity on molecular weight of the polymer, reptation etc will be included in the discussion

Other resources that you may find useful:

- P. W. Atkins, "Physical Chemistry", Freeman and Co. 1990 (or a more recent edition)
- H. Fujita, "Polymer Solutions", Elsevier, 1990.
- P. C. Hiemenz, "Polymer Chemistry: The Basic Concepts", Dekker, 1984.
- Physical Properties of Polymers Handbook; J. E. Mark, editor; American Institute of Physics, 1996.
- H. Morawetz, "Macromolecules in Solution", Krieger Publishing Co., 1975 (reprinted in 1983).
- E. G. Richards, "An introduction to physical properties of large molecules in solution", Cambridge University Press, 1980
- P.G. De Gennes, "Scaling Concepts in Polymer Physics", 1979.
- Bill Graessley, *Polymer Liquids and Networks*: *Structure and Properties*, Garland Science, 2003
- "*Macromolecules: An introduction of Polymer Science"*, Edited by F. A. Bovey and F. H.
- Winslow, Academic Press, 1979
- Paul J. Flory, "*Principles of Polymer Chemistry"*, Cornell University Press
- Paul J. Flory, *Statistical Mechanics of Chain Molecules*, Hanser Publishers

- Charles Tanford,, "*Physical Chemistry of Macromolecules"*, John Wiley
- M. Doi and S. Edwards, "*The Theory of Polymer Dynamics*", Oxford University Press

Historical Aspect of Polymer Science

- Herbert Morawetz, *Polymers: The origins and Growth of a Science*, Dover Publication 0-486-68732-5
- David A. Hounshell and J. K. Smith, "Science and Corporate Strategy: DuPont R & D, 1902-1980" Cambridge University Press.