MSE / CHEM / CHBE 6571

Physical Chemistry of Polymer Solutions

Spring 2016

Syllabus

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Class Times: M / W / F 11:00-12:00
Lecture room: MRDC 3403
Office hours: By appointment, or just drop in! I may schedule some regular hours once the semester is underway.

Course aspirations:
Establish fundamental understanding of behavior of polymer and biopolymers and in dilute and concentrated solutions, liquid crystals and gels. By the end of the course it is anticipated that students will understand size, shape, dynamics, viscosity and phase behavior of macromolecules in solution well enough to think critically about current literature. One of the main applications of polymer physical chemistry is to macromolecular characterization. Appropriate links will be established to that practical discipline. Although the course has a macromolecular theme, there are natural extensions to dispersions of colloids and nanoparticles.

Course Grading:

Homework	50%
Tests: 2 Midterms & Final Exam	30%
Inreach Service Contribution (ISC, detail below)	20%

Midterms: Probably take-home but with a day or two off from lecture.

ISC: The Inreach Service Contribution will be your legacy to improved graduate polymer/biopolymer education. The ISC contribution can take many forms. If our class includes a significant number of students who lack background material (e.g., they never heard of intrinsic viscosity) a student with that training could lead an ISC section for them. Other ISC contributions might include improvements to web-based education for GT and other institutions in APTEC (the Applied Polymer Technology Extension Consortium).

Important Dates

Martin Luther King Holiday	Monday, January 18
Midterm 1	Friday, February 12 (Tentative)
Midterm 2	Friday, March 18 (Tentative)
Spring Break	Monday-Friday March 21-25
Final Exam	Wednesday May 4, 8 am – 11 am

Textbooks: Rather than a single recommended text, I suggest you buy at least one text! The lectures will follow along the lines of the Virtual Text on the LSU Macromolecular Studies Group site. This is now being ported to a more modern site (far less elegant, but smartphone-friendly). Contributions to that effort are a valid ISC possibility. Here are some suggestions:

LSU Virtual Text: http://macro.lsu.edu/corecourses/msweb4 (>>>Virtual Text) Other links on this site are helpful, too!

QD381.H52 2007 P.C. Hiemenz and T. P. Lodge, Polymer Chemistry, Second Edition, CRC Press (2006). This is a very good text, pitched at an introductory level.

QD281P6F58 P. J. **Flory**, Principles of Polymer Chemistry. The Bible. Written in 1953 by the eventual Nobelist, it is still very valuable. Many of the seminal ideas in polymer science are found here. Like all Flory work, it is lucidly written. The notation is something of a standard.

QD471T24C **Tanford**, Physical Chemistry of Macromolecules, Wiley (1961). Tanford is a solid book that clearly presents the basics. Despite its age, it is still often cited. The notation and symbols are sometimes non-standard, but do not let this get in your way.

QD381H.Y36 **Yamakawa**, Modern Theory of Polymer Solutions (out of print now). If you like lots of equations, are interested mostly in dilute solutions, and already know something of the subject, here is your text! Have a look. This classic book is now on-line.

QH505 K. E. **Van Holde**, Physical Biochemistry. There are several editions…all are good. A pocket size book, slicker than Tanford with much of the same information in a highly appealing form. Try reading this whenever nothing else makes sense. Strongly recommended.

QD471.M65b H. **Morawetz**, Macromolecules in Solution. Sort of a cross between Tanford and Billmeyer. Less development more results-oriented. A good place to check before embarking on a new line of research, since there are polymer-specific results and lots of references to the old literature.

TA455 J. D. **Ferry**, Viscoelastic Properties of Polymers. We will refer to this book when and if we get to viscoelastic behavior. It is comprehensively written by the pioneer in the field.

QD471.F664 P. J. **Flory**, Statistical Mechanics of Chain Molecules. The title is very descriptive. How to predict the behavior of macromolecules. We won't do too much with it, but look anyway.

QD381.G45 P. G. **de Gennes**, Scaling Concepts in Polymer Physics. A collection of thoughts from one of the most imaginative minds in modern polymer science. In vivid contrast to Flory or Yamakawa, de Gennes' approach is always simple--on the surface. The ideas that launched the "French Revolution" polymer science and helped de Gennes win a Nobel prize in Physics are presented.

QD381.R52 E. G. **Richards**, An Introduction to Physical Properties of Large Molecules in Solution, Cambridge Univ. Press (1981). This is a tersely written book, with few flashy figures. Yet it provides very valuable insights, is cheap, and has some good problems.

QH345.C36 C. R. **Cantor** and P. R. **Schimmel**, Biophysical Chemistry, Parts I - III. This is a fantastic series of books with extremely lucid explanations of many aspects of polymer chemistry. Oriented towards the biopolymer community, it nevertheless provides valuable insights for polymers in general, and it is highly recommended.

QC173.4.P65 R83 2003 530.4'13-dc21 **M. Rubinstein and Ralph H. Colby**, Polymer Physics. Very readable physics-based approach.

QD281.P6E27 1986 547.7 85-29854 **M. Doi and S. F. Edwards**, The Theory of Polymer Dynamics. A detailed and expert view about polymers in motion, not limited to solutions.

Course Plan (subject to change)

Part 1. Basics (about

- Review Solution Thermodynamics in General
  - *Partial molar quantities, standard states, phase equilibria*
- Fundamentals of Macromolecular Solution Thermodynamics
  - *Partial specific quantities, phase equilibria, FH theory, Virial Coefficients*
- Viscosity (ISC?)
- Molecular Weight & Molecular Weight Distribution (ISC?)
- Single Chain Conformations & Polymer Dimensions
  - *Rotational isomeric states, Helices, Coils – ideal and expanded states, Persistent chain, Ising Chain*
- Scattering from Macromolecular Solutions (ISC?)

Thermodynamic and particle viewpoints, molecular weight, size, virial coefficients

Transport Methods

SLS, AUC, GPC-AF4/MALS

Part 2. Special Topics (Possible Topics)

Dilute and Semidilute solutions

Osmotic Pressure, Real chains in good solvents, Overlap threshold, Semidilute behavior, Correlation lengths and functions

Confined solutions

Against repulsive walls, in porous media

Polyelectrolyte solutions

Condensation and screening charges, Chain stretching, Salt effects, Interchain ordering, Osmotic pressure.

Return to Polymer Solution Viscosity

Rouse model and internal friction effects, Dynamics in good solvents, Static viscosity

Polymer gels & hydrogels

Swelling, Collapse, Elasticity, Dynamics

Dissolution of Solids and Drying of Solutions

Dispersion methods, Coffee rings.

Polymer lyotropic liquid crystals

Phase relations, solubility issues, processing considerations

Novel methods for studying polymer solutions