MatSE 445: THERMODYNAMICS, MICROSTRUCTURE AND CHARACTERIZATION OF POLYMERS

Course Designation: Formerly designated PlmSE 409; this is a required course in Polymer Science and Engineering, and an elective course for other options.

Catalog Description: The properties of individual polymer chains. Theoretical and experimental techniques pertaining to the characterization of polymeric microstructure.

Course Description: This course deals with the properties of individual polymer chains and their characterization. Elements of chain microstructure, molecular weight and linear polycondensation are reviewed, followed by a discussion of multifunctional polycondensation and gelation theory. Next, the application of probability theory to the characterization of polymer chain microstructure, compositional drift and the terminal and penultimate models is considered. A discussion of chain conformation and random flight then leads into the thermodynamics of polymer mixtures and the Flory-Huggins equation. After reviewing the determination of absolute molecular weights and viscometry, size exclusion chromato-graphy is discussed with emphasis on universal calibration and long chain branching. Finally, the application of infrared and NMR spectroscopies to the characterization of polymers are discussed.

This course is offered annually, in the fall semester, in the Department of Materials Science and Engineering.

Prerequisites: MatSE 443

Textbook: Fundamentals of Polymer Science by P. C. Painter and M. M. Coleman.

Course Objectives: The objectives of this course will enable students:

1. to gain a knowledge of probability theory it as applied to multifunctional polycondensation, gelation, sequence distribution and polymer microstructure.
2. to understand the importance and underlying principles of polymer chain conformation and the thermodynamics of polymer solutions and blends.
3. to gain a basic knowledge of the major characterization tools used to determine polymer molecular weight, its distribution and polymer chain microstructure.

Topics Covered:

1. A review of polymer microstructure and molecular weight.
2. The statistics of linear and multifunctional polycondensation.
3. Gelation theory and random branching without network formation.
4. The application of probability theory to copolymer sequence distribution.
5. The terminal and penultimate models of copolymerization.
6. Chain conformations, random flight and an introduction to rubber elasticity.
7. The thermodynamics of polymer solutions and blends— Flory-Huggins theory.
8. Solubility parameters, polymer blends and a guide to miscibility.
9. A review of absolute molecular weight measurements and viscometry.
10. Size exclusion chromatography and the universal calibration curve.
11. Determination of long chain branching.
12. Vibrational and NMR spectroscopies and their application to polymers.

Class Schedule: 3 credit course offered annually, 3 meetings per week for 50 minutes.

Course Outcomes: Upon completion of the course the student should be able to:

1. describe the different types of polymer microstructure, calculate molecular weight averages and determine the theoretical gel point of a multifunctional system. polycondensation.
2. understand basic probability theory and be able to manipulate pertinent equations.
3. understand the concept of the terminal and penultimate models and be able to test whether or not given data is consistent with either model.
4. describe chain conformations, the end-to-end distance, and the radial distribution function and describe the relevance of these concepts to rubber elasticity.
5. understand the basic Flory-Huggins theory, solubility parameters and the χ parameter and be able to describe their relevance to phase behavior of polymer solutions and blends.
6. calculate molecular weights and intrinsic viscosity from size exclusion chromato-graphy data via the universal calibration method and be familiar with the SEC-intrinsic viscosity method used to estimate the degree of long chain branching.
7. understand the basics of infrared spectroscopy. He or she should be able to use the group frequency approach to identify (co)polymers and be able to discern whether or not infrared spectroscopy is an appropriate characterization tool for a particular problem.
8. understand the basics of NMR spectroscopy. He or she should be able to use NMR to identify and analyze selected (co)polymers using ^1H NMR, be familiar with its application to determine tacticity and other microstructures in polymers, and be able to discern whether or not NMR spectroscopy is an appropriate characterization tool for a particular problem.

Assessment Tools: 3 in-class closed book exams. 10-12 homework problem sets including those that use real experimental data and require judgment and an appreciation of the effect of errors on calculated results.

Professional Component: The lecturer has worked in industry and throughout this course the practical scientific and engineering principles pertaining to polymer microstructure are emphasized.

Prepared by: Michael M. Coleman, February 2002.

MAP TO DEPARTMENTAL OUTCOMES (For further detail, see coursebook)											
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
1	1	2	2	1	3	2	2	3	2	2	1

MAP TO DEPARTMENTAL OBJECTIVES (For further detail, see coursebook)						
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
2,3	1,2,3	2,3				