MATSE 443: INTRODUCTION TO THE MATERIALS SCIENCE OF POLYMERS (Formerly PLMSE 406)

Course Designation: This is a required course in the Polymer option, and an elective in all other options.

Catalog Description: Introduction to the nature and structure of high polymers. Characteristics of polymers and polymer systems.

Course Description: This course is an introduction to the field of polymer science and engineering, providing an overview of the synthesis and structure of these materials; the crystalline and glassy states; solution properties and phase behaviour; mechanical and rheological properties.

Prerequisites: CHEM 38, MATH 231, PHYS 214

Textbook: Fundamentals of Polymer Science, Painter and Coleman, 2nd ed.

Course Topics:

I. The nature of polymer materials and polymer microstructure: including branching, networks, tacticity and copolymers.
II. Polymer synthesis: step-growth and chain polymerizations.
III. Kinetics of polymerization: the kinetics of step growth and free radical chain polymerizations; relationship to molecular weight.
IV. Statistics of step-growth polymerization: the use of statistics in describing molecular weight distributions in step-growth polymerization.
V. Copolymerization: the kinetics of free radical copolymerization.
VI. Structure: chain conformations, amorphous polymers, and the morphology of semi-crystalline polymers.
VII. Crystallization, melting and the glass transition: an introduction to crystallization kinetics, melting and glass formation.
VIII. Polymer solutions: the Flory-Huggins theory and phase behaviour.
IX. The measurement of molecular weight: osmometry, light scattering, viscosity and size exclusion chromatography.
X. Mechanical and rheological properties: stress/strain behaviour, visoelasticity, non-linear mechanical and rheological behaviour, ultimate properties.

Course Objectives

1. Develop a basic understanding of the reaction mechanisms involved in polymer synthesis and the kinetics of these reactions.
2. Provide the basic concepts of polymer chain architecture, structure and morphology, with particular emphasis on the relationship between chemical structure (chain architecture) and the morphology of the solid state (semi-crystalline vs. amorphous polymers)
3. Provide a basic knowledge of the thermal properties of polymers, particularly the crystallization temperature and elementary aspects of crystallization kinetics, the melting temperature and the glass transition; to teach how these properties depend on structure.
4. Develop basic knowledge of the solution properties of polymers, interactions and the relationship to chemical structure, including phase behaviour and the measurement of molecular weight.
5. Provide the essentials of polymer structure/property relationships, so that simple predictions for design can be made.

Course Schedule: 3 credit course offered twice annually (Fall & Spring);
3 meeting times (50 min each) per week

Course Outcomes

1. Given a polymer structure the student should be able to specify a general synthesis scheme and predict molecular weight averages as a function of reactant concentration and monomer conversion.
2. A student should be able to calculate number and weight average molecular weight from a given distribution.
3. Given a polymer, a students should be able to specify methods for the measurement of number and weight average molecular weight and also the entire molecular weight distribution.
4. A student should be able to describe basic chain conformations and calculate the average chain end-to-end distance.
5. Given micrographs of polymer materials the student should be able to identify the morphology and how it depends upon crystallization conditions.
6. A student should be able to describe basic aspects of the phase behaviour of polymer solutions and blends and how this behaviour depends on the Flory-Huggins χ parameter.
7. The student should be able to predict the basic stress/strain and viscoelastic behaviour of polymer materials based on a knowledge of structure and thermal properties (Tm and Tg).
8. The student should be able to apply the Bottzmann Superposition Principle and WLF equation to the prediction of viscoelastic behaviour.
9. Given simple material requirements (optical transparency for bottles, flexibility and toughness for buckets, etc), a student should be able to select the most suitable polymer material for a given application.

Assessment Tools (Outcomes)

I. In-class closed book exams
II. Problem sets and homeworks that allow student collaboration and team work.
III. Annual (spring) student questionnaires; student presentations (spring).

Assessment Tools (Objectives)

Annual (spring) student questionnaires; specific SRTE questions; exit interviews

Professional Component: The course addresses the fundamentals of polymer science and engineering. Emphasis is on providing a broad knowledge of the field, and how the specifics of a polymer define the structure/property relations for a polymer. An appreciation of how the structure/property relations become relevant to real life problems (applications) and materials design choices follows naturally.

Prepared by: P.C. Painter & E. Manias, Sept. 2000 (Revised May 2001, Feb. 2002)

MAP TO DEPARTMENTAL OUTCOMES (For further detail, see coursebook)											
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
1,7,8		1,5,9									1,8,9

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