Engineering Faculty Document No. 18-04

TO: The Engineering Faculty

FROM: The Faculty of the School of Materials Engineering

DATE: January 15, 2005

RE: New Dual-Level Course, MSE 525

The faculty of the School of Materials Engineering have approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

MSE 525 Structure-Property Relationships of Engineering Polymers
Sem. 2. Class 3, Cr. 3. (Offered in Alternate Years)
Prerequisites: Senior or graduate standing; junior by permission of instructor.

Description: Structure-property relationships developed for commodity and engineering resins. Focus on connecting bonding and polymer structure (i.e. molecular weight, tacticity, crystallinity as it regards spherulites) to mechanical (yield phenomena and fracture) and thermomechanical behavior (viscoelasticity). Thermal characterization techniques, including DSC, TGA, TMA and DMTA. Flow of polymer melts related to common melt processing techniques (i.e. extrusion and injection molding).

Reason: This class has now been offered two times, in Spring 2003 (28 students) and Fall 2004 (19 students), with good enrollment. The purpose of this course is to develop an understanding of how bonding and structure in a polymer affects its properties, particularly those properties associated with their use in structural applications. Because of the emphasis on structural applications, commodity and engineering resins are the primary focus in this course. These resins alone contribute to over 200 million tons of usage annually. The content of this course has been coordinated with MSE 597Y (polymer synthesis course) and CHE 544 (polymer physics course).

A. H. King, Head
School of Materials Engineering

MSE 525
Structure-Property Relationships in Engineering Polymers
Instructor: R.W. Trice, rtrice@purdue.edu MSEE 386B, 494-6405

Course Description: Structure-property relationships developed for commodity and engineering resins. Focus on connecting bonding and polymer structure (i.e. molecular weight, tacticity, crystallinity as it regards spherulites) to mechanical (yield phenomena and fracture) and thermomechanical behavior (viscoelasticity). Thermal characterization techniques, including DSC, TGA, TMA and DMTA. Flow of polymer melts related to common melt processing techniques (i.e. extrusion and injection molding).

Prerequisite: Senior or graduate standing; junior by permission of instructor

Goals: Students should be aware of the basic advantages and limitations of common commodity and engineering polymers. Specifically, they should know how polymer bonding and structure affects thermal, mechanical, and processing properties. Students should be capable of making assessments of material suitability for an application.

Objectives:
Upon completion of this course, a student should be able to:

- Identify microstructural differences between thermoplastic, thermosetting, and elastomeric polymers and how these affect thermal and mechanical properties.
- Discuss the crystalline structures of thermoplastic polymers, including nucleation and growth of spherulitic structures and how molecular weight, tacticity, and cooling rate affect the morphology of the crystals.
- Discuss entropy elasticity as it relates to elastomeric behavior.
- Compare and contrast the yield and fracture mechanisms of polymers with metallic and ceramic materials.
- Explain viscoelasticity from a microstructural viewpoint, and its manifestations in polymeric mechanical behavior, including mathematical modeling of creep and stress relaxation behaviors of simple and complex systems (including the Zener model).
- Use the WLF equation and develop master curves for amorphous polymers, and perform Boltzmann superposition calculations.
- Interpret the results from common thermal characterization (DSC, TGA, TMA, and DMTA) techniques and relate them to polymer structure.
- Discuss polymer flow as it relates to melt-processing techniques (like extrusion and injection molding) and how polymer chain morphology affects processing.
- Perform simple modeling calculations of the cooling behavior of polymers from the melt.

Text: Principles of Polymer Engineering by N.G. McCrum, C.P. Buckley, and C.B. Bucknall, 2nd Edition (Oxford Press). This book will be supplemented with other handouts.
Assessment: Three Exams (80%), Homework (15%), Paper (5%)

Weekly syllabus:
Week 1: Introduction/Important Engineering Polymers

Week 2: Role of Molecular Weight and Bonding on Polymer Properties

Weeks 3-4: Structure of Amorphous, Crystalline, and Elastomeric Polymers (Including Entropy Elasticity)

Week 5-6: Thermal Characterization of Polymers

Week 7-10: Polymer Viscoelasticity

Week 11-13: Mechanical Properties of Polymers

Week 14-15: Melt Processing of Polymers (Including Injection Molding and Extrusion)