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Macromolecular Physics

Research Interests

Nanoscale Determination of Physical Properties of Polymer Glasses Using Molecular Probes

Glasses have been the subject of a great deal of interest in the last fifty years. Models of structure recovery have provided an adequate understanding of the metastable behavior of glasses. However, these models are known to provide a very incomplete picture making glasses an area where understanding still lacks severely. Most of the work in this area has centered on following the recovery towards equilibrium of macroscopic properties such as volume and enthalpy after various thermal histories leading the samples to the glass phase. Recent studies have shown that the effect of size on the glass transition can be followed up to the nanometer scale. In previous work, we developed a methodology using infrared spectroscopy and molecular probes to quantitatively evaluate the presence of rigid amorphous regions in semi-crystalline polymers. Changes in thermal history can lead to variations in the relative phase composition of the sample. This implies that the evolution of glasses could possibly be followed using molecular probes. We use infrared imaging techniques to follow the changes in molecular probes during the structural recovery of glasses. Variations in probe position as well as conformational changes in the probe could lead to better understanding of the glass transition, and could lead to improved models of structure recovery and better predictive ability.

Investigation of the Interactions of Water Molecules with Biopolymers

All biopolymers such as starch and cellulose have structural and physical properties that are strongly related to their water content. Although the role of water is still not well understood, it is thought that it may modify the mobility of polymer chains and influence the degree of entanglement. In addition, the crystalline content of the polymer as well as the molecular conformations of the chains are related to the pH and hence the amount of water. Since in addition to the quantity of water, the origin of the biopolymer has a bearing on the chain morphology, it is difficult to make a comprehensive study of the effect of water content. Studies that have approached the problem have mostly been centered on the relationship between physical properties and water content, without addressing the biopolymer water interaction. During recent studies, we have studied the phase content of amylose, a major component of starch, using Fourier transform infrared spectroscopy (FTIR) and differential scanning calorimetry (DSC). We found that although the water content was important in determining the phase content, of more significance was the fact that the way the water was absorbed by the sample had an even greater influence on the phase content. However, the water-biopolymer interactions were not further explored. We investigate these interactions using FTIR spectroscopy combined with DSC and thermogravimetric analysis to measure the water-related weight loss. Using these methods, for a systematic sampling of starches and cellulose from different sources, the chemical interactions between water and polymer chains will be investigated. Since it is expected that a major effect of water molecules on the polymer chains will be the changes in molecular conformations the comprehensive study of the water-biopolymer interactions will play an important role in determining the phase composition of starches and cellulose and by the same way, their physical properties. Determination of these will yield improvements in the usefulness of these materials.

Selected Publications

P. Bernazzani, R. F. Sanchez, (2009) “Structural and Thermal Behavior of Polystyrene Thin Films Using ATR-FTIR-NanoDSC Measurements” J. of Thermal Analysis and Calorimetry, 96, 727-732.

Y. Meng, P. Bernazzani, P. A. O'Connell, G. B. McKenna, S. L. Simon, (2009) "A New Pressurizable Dilatometer for Measuring the Time-Dependent Bulk Modulus..." Review of Scientific Instruments, 80, 053903-1-053903-9.

P. Bernazzani and R. F. Sanchez, (2008) “ Effect of Substrate Interactions on the Melting Behavior of Thin Polyethylene Films” *European Physical J. – Soft Matter*, 26, 427-434.

P. Bernazzani, R. F. Sanchez, M. Woodward, S. Williams, (2008) “Determination of the Glass Transition Temperature of Thin Unsupported Polystyrene Films Using Interference Fringes” *Thin Solid Films,* 516, 7947-7951.

P. Bernazzani, V. K. Peyyavula, S. Agarwal, R. K. Tatikonda, (2008) "Evaluation of the Phase Composition of Amylose by FTIR and Isothermal Immersion Heats" Polymer, 49, 4150-4158

Z. Ferhat-Hamida, H. P. Nguyen, P. Bernazzani, A. Haine, G. Delmas (2007) “LLDPE's grown with Metallocene and Ziegler-Natta catalysts: events in the melt and FTIR analysis” *J. of Material Science*, 42, 3138-3154.

Recent Thesis Topics

Cinzy R. Dozier (2011) “Analysis of the effects of microgravity on the the recrystallization of PE thin films”

Vasudeva R. Chintamsetti (2011) “*In vitro* analysis of lipid rafts: identification, separation and quantitative analysis”

Brian A. McKinley (2010) “Study of structural requirements of the binding pocket of alpha-amylase, the enzyme responsible for the biodegredation of amylose”

D. Prasad Obulasetti (2010) “Preparation of biodegradable polyethylene-starch blend investigation of the effect of nanoparticles in enhancing the stability of the blend”

Meghan R. Ruggles (2010) “Evaluation of the interactions between titanium dioxide nanoparticles and polystyrene chains in nanothin films”