THE CITY COLLEGE OF NEW YORK
CHEMICAL ENGINEERING DEPARTMENT
PRESENTS

Professor Jeffrey Koberstein
Columbia University

Monday, March 6, 2017
Seminar will be held in ST-160 (Lecture Hall) at 2:00 PM
Reception will be held in Steinman Hall, Exhibit Room from 3:15 – 4:00 PM

Polyacetics: Biocompatible Polymers that are Both
Thermoresponsive and pH-Degradable

The fundamental nature of polymer applications has changed markedly over the years. While early applications called for polymers that were strong and light, resistant to chemicals and environmentally inert, today’s applications demand smart polymers that can shrink, expand, thicken, or change effectively any physical, optical or electronic property in response to a host of different external stimuli. Smart polymers have been developed to respond to almost every conceivable stimulus: temperature, pH, light, magnetic and electric fields, ultrasound, guest-host interactions, electron transfer (oxidation-reduction), the presence of compounds such as sugars, salt, antigens, enzymes, and even CO₂. The stimuli-responsive polymers that have received the most attention to date are those that respond to temperature, in particular polymers with a lower critical solution temperature (LCST) that lose solubility upon heating.

Water soluble TRPs are particularly important because of a myriad of medical applications including bioseparations, tissue scaffolds, actuators/artificial muscles and drug delivery vehicles such as block copolymer micelles, hydrogels, nanoparticles and nanoparticle-polymer hybrids. In biomedical applications, it is desirable to tune the LCST so that the polymer loses solubility at a specific, biologically relevant temperature. For example, in hypothermia-targeted drug delivery, a drug delivery vehicle is designed to be stable in solution at physiological temperature (~38°C) but to fall out of solution upon encountering a tumor with a slightly elevated temperature associated with hyperthermia. In this fashion, drug-laden micelles can be concentrated and immobilized within a tumor. Controlled release of the drug is possible if the drug delivery vehicle comprises a mechanism for biodegradation within the tumor microenvironment, which is subject to acidosis with a pH of 5-6.5.

The seminar will discuss the synthesis and characterization of an exciting new family of water-soluble, temperature-responsive polyacetals with remarkable LCST temperature response. The new polyacetals are the first synthetic LCST polymers to be intrinsically biodegradable. Furthermore, their degradation mechanism is unique, producing neutral degradation products in acidic environments which do not cause inflammation. The LCST behavior of aqueous polyacetal solutions is extraordinary: the LCST cloud point transitions are sharp, occurring over a range of 3-5°C, show almost no hysteresis between heating and cooling cycles, and the cloud point temperatures (CPTs) can be predicted directly from the molecular structure of the monomers and tuned to high precision anywhere within a range of about 6-80°C because they are linearly dependent on the number of methylene and/or ethylene oxide units comprising the monomers. The LCST behavior is modeled successfully with atomistic simulations and by coarse graining.
Methods to include backbone click chemistry functionality will be detailed allowing the polyacetals to carry a wide variety of payloads such as scent compounds, and it is demonstrated that hydroxyl-functional, azide-functional and alkyne-functional macromonomers can be readily prepare. The former allows the synthesis of completely biodegradable polyurethanes, while the latter two macromonomers are used to prepare end-linked block copolymers by click chemistry for use as biodegradable surfactants and micellar delivery vehicles. Finally, we show that a number of main-chain polymer-drug conjugates can be readily prepared for the treatment of cancer. Because the polymers are temperature-responsive, these polymers have been used in an application for a paint-on antimicrobial bandage, which sticks to the skin at body temperature, but can be easily removed simply by rinsing with cold water.

Dr. Koberstein received a Bachelor's degree in Chemical Engineering from the University of Wisconsin, and a Doctorate in Chemical Engineering from the University of Massachusetts in 1979. After a year of postdoctoral research at the Centre de Recherches sur les Macromolecules in Strasbourg, France, he joined the Chemical Engineering faculty at Princeton University. From 1986-1999 he was a member of the Polymer Program within the Department of Chemical Engineering and Institute of Materials Science at the University of Connecticut, where he was Associate Professor (1986-89) and Professor (1989-99) of Chemical Engineering. He was named Distinguished Professor of Engineering at Connecticut in 1998, one of the first two professors in the Engineering School to hold that title. In 2000 he joined the faculty of Chemical Engineering at Columbia University and was appointed as the Percy K. and Vida L. W. Hudson Professor of Chemical Engineering in 2003.

Prof. Koberstein was co-recipient of the 1984 Arthur K. Doolittle Award of the American Chemical Society for development of the technique of simultaneous calorimetry and synchrotron x-ray scattering, and received the 1990 American Cyanamid Academic Award in recognition of his contributions to polymer surface science; the latter award recognizes excellence in the science and art of chemical synthesis, and in training young people in its practice. In 1992, Dr. Koberstein was elected as a fellow to the American Physical Society. He received the Stine award from the American Institute of Chemical Engineers in 2006 and was elected a fellow of the Institute in 2007. Prof. Koberstein has held guest professorships at the Max Planck Institute for Polymer Research in Mainz, Germany; Kyushu University in Japan, and the Universite’ Montreal in Canada. Current research interests include modification and patterning of functional polymer surfaces, surface modification of nanoparticles and the development of smart polymers for biomaterial applications.

Dr. Koberstein has also been active in service, chairing the American Physical Society Division of High Polymer Physics in 1996, and the Materials Science and Engineering Division of the American Institute of Chemical Engineers in 2006. He was Director of the University of Connecticut Polymer Science Program from 1994-98, directed the NSF Graduate Traineeship Program in Environmental Aspects of Plastics Recycling at UCONN from 1994-1999, co-directed the CCNY-Columbia NSF-IGERT with Mort Denn and chaired the Columbia University Chemical Engineering Department from 2000-2005.

Professor Koberstein has received three teaching awards: the Rogers award from the University of Connecticut in 1998, the Alumni Association Distinguished Faculty Teaching Award in 2011 and the Kim Faculty Involvement Award in 2015, the latter awards presented by the School of Engineering at Columbia University.