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CHEMICAL AND BIOLOGICAL ENGINEERING DEPARTMENT SEMINAR SERIES

New Concepts in the Design of PEMs Using Polymer Blends

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Time: Wednesday, October 24; 3:15 – 4:30 pm

Location: Perlstein Hall Auditorium

Abstract

Despite the gains that have been made in fuel cell technology over the last decade, major barriers to implementation of commercial fuel cells remain. One of the key shortcomings of contemporary fuel cells is the proton exchange membrane (PEM), which serves as the electrolyte for proton transfer and as the separator to prevent direct physical mixing of the hydrogen and the oxygen at the anode and cathode, respectively. The state-of-the-art polymer electrolytes are perfluorosulfonate ionomers. The next generation of fuel cells being designed for transportation require improvements in several aspects of the current membranes, including their high cost, insufficient durability, especially at higher temperatures, poor resistance to fuel crossover, unacceptable water transport rates and inadequate properties above 100 C. A higher temperature PEM that is less sensitive to water can improve the efficiency of a fuel cell by speeding up the reaction at the anode, and higher operating temperature also improves the CO tolerance and reduces the need for pressurization of the fuel cell. Developmental work on new membrane materials involves mostly the synthesis of new sulfonate ionomers based on aromatic hydrocarbon polymer backbones. These materials, however, are likely to have similar nanostructures as the perfluorosulfonate ionomers, i.e., water-swollen ionic channels that form due to aggregation of water and the sulfonic acid groups and similar deficiencies as the perfluorosulfonate membranes with regard to water management and fuel crossover. A relatively high concentration of water is required to develop a percolation pathway of water-swollen “ionic” channels, and water concentration and ion transport are coupled in water-swollen perfluorosulfonate membranes. As a consequence, the transport and mechanical properties of the membranes are coupled; that is, improving the conductivity by increasing ion-exchange capacity (IEC) or water concentration degrade the mechanical properties and vice versa.

Despite the considerable research on the synthesis and characterization of new membrane materials, surprisingly little work has been directed at controlling the morphology of PEMs. This is surprising, because it is the ionic microstructure that controls the conductivity and the transport of water and methanol through the membrane. In this talk, we will discuss the properties of PEMs produced from polymer blends and how the morphology of the blend affects transport properties. The blends were prepared from a conductive polymer (i.e., an ionomer) and either a non-conducting polymer or a poorly conducting polymer. With a two-phase blend, one can decouple the mechanical and transport properties and, in principle, optimize both independently. In our case, the non-conducting phase provides mechanical stability and durability to the PEM, while the ionomer provides the ionic pathway for conductivity. We will also discuss how electrical field alignment of the conductive phase in a polymer blend can significantly improve conductivity.

Biography

Bob Weiss is presently the Board of Trustees Distinguished Professor and UTC Professor of Advanced Materials and Processing in the Department of Chemical Engineering and the Institute of Materials Science at the University of Connecticut, Storrs. He received a Bachelors Degree from Northwestern University and a Ph.D. from the University of Massachusetts, Amherst (Polymer Engineering). For the past three decades, he has performed and directed fundamental and applied research in the area of ionomers, with specific research areas including, polymer blends, wetting of thin polymer films, electrically conductive polymers, hydrophobically modified hydrogels and shape memory elastomers. Recently, he has been researching novel approaches for the design of membranes for PEM fuel cells.