



Chris Cornelius

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Professor Cornelius is a faculty member in the Department of Chemical and Biomolecular Engineering at the University of Nebraska and an Editor of the Journal of Materials Science. His work investigates fundamental material interrelationships between structure, physical properties, and transport using synthetic polymers, ionomers, hybrid organic-inorganic materials, and sol-gel glasses. He teaches graduate and undergraduate thermodynamics, polymer physics, transport phenomena, and separations. Before academia, he was a staff scientist at Sandia National Laboratories developing hydrocarbon ionomers, fuel cells (DMFC, PEM, AEM), and gas separations (sol-gel films and polyimide nanocomposites). This work resulted in numerous collaborations with industry (Sharp Corporation, GM, Ford, Ballard, Toyota, Honda, Exxon Mobil, Chevron Texaco, Teledyne, United Technologies), National Laboratories (LANL, PNNL, ONR, Savannah River), and university faculty throughout the world. Prior to his Ph.D., he was as a Process Engineer at 3M working on non-woven media for particle filtration and a Research Engineer with Dow Plastics producing metallocene based polyolefins

“Multi-block Quaternary Ammonium Ionomer Composition and Processing Relationships Utilized to Improve Properties and Function”

Abstract

Quaternary ammonium (QA) ionomer composition and processing efforts are needed to improve their brittle properties when dry and wet-film durability. These research efforts impact functional group distribution, water and ion-transport, and physical properties related to film toughness, and degradation resistance. A QA ionomer dichotomy exists between ion conductivity and its physical properties. Increasing film conductivity leads to undesirable water swelling that degrades its strength, and dimensional stability. Numerous QA synthetic efforts are devoted to creating simultaneous improvements in ion transport and physical properties. Typical QA ionomer film processing methods involve heterogeneous conversion, which produces films that only become flexible if plasticized by water. This inherently brittle film property contributes to the sparse literature corresponding to their physical properties. In this work, QA ionomers were studied based upon composition, block length, and processing using a multiblock aminated poly(arylene ether sulfone) copolymers (Q:N[X:Y]) and aminated polyphenylene (qPP). Flexible multi-block QA ionomer films were created using either a quaternized polyphenylene (qPP) or quaternized (Q:N) multi-block copolymer using benzyl tetramethyl polysulfone (BTMP). For example, a multiblock Q:N[24k:14k] film with an ion-exchange capacity (IEC) of 1.9 was flexible when dry, and it had a hydroxyl conductivity (σ_{OH}) of 70 mS/cm at 25 °C. This remarkable result is different from the vast majority of all QA materials reported in the literature, which are created by solid-state conversion of R-Br groups into R-N(Me)₃ by immersion in a N(CH₃)₃ solution or similar group. In general, Q:N[X:Y] and aPP solution-cast films were tougher and more ductile than solid-state conversion of R-Br into R-N(CH₃)₃ using trimethylamine (TMA). All Q:N[X:Y] multi-block ionomer films created by heterogeneous conversion were brittle. These composition-processing dependent properties are attributed to improved phase separation between hydrophobic and hydrophilic domains that improves interconnectivity between domains, and distribution of functional groups throughout the film. Fundamental material science efforts are critical to the creation of new knowledge and transformative technologies. However, understanding and controlling material assembly is a material science cornerstone. The focus of this talk will be an examination of composition and processing as it relates to a reduction in energy utilization from water desalination to energy storage using flow batteries.

Tuesday, February 5th

1:00 – 1:50PM | Spahr Auditorium