179f Structural Examination of Advanced Sulfonated Polyarylenethioethersulfone Polymer and Copolymer Membranes for Fuel Cell Applications

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Fuel cells have received considerable attention from researchers due to their promising potential as a pollution-free energy source and an alternative for oil-based fuels. Small, light-weight fuel cells operating between 70 and 140 ^{o}C enable numerous portable power sources, which are desired for applications ranging from automotive to unmanned aerial vehicles. Critical to the efficiency of these fuel cells is the membrane, which serves to separate reactant gases and act as an electrolyte for transporting protons from anode to cathode. Highly sulfonated endcapped polyarylenethioethersulfone polymers show considerable promise for membranes operating at these elevated temperatures (>120 ^{o}C). The homopolymer (SPTES100) and its copolymers (SPTES 80, SPTES 70, SPTES 60, SPTES 50) have shown proton conductivity superior to Nafion (SPTES100, SPTES 80 and SPTES 70 are 3-4 times higher than Nafion at elevated temperatures). Additionally, these polymers exhibit excellent thermal and mechanical properties and form tough, flexible films.

The high proton conductivity of sulfonated endcapped polyarylenethioethersulfone polymers is attributed to the presence of two sulfonation sites per repeat unit of the monomer. Small angle neutron scattering studies have shown the presence of nanoscale water domains on the order 4-5 nm. The size of these domains depends on the size and valence of the counterion exchanged with $SO3^{-}$. In-situ neutron scattering experiments of the membranes subjected to a range of humidities showed an increase in the domain size with increasing humidity. Appearance of a broad peak at higher temperatures and humidities (i.e. 85 ^{o}C and 85%RH) indicated an onset of short range correlations between water domains. However, these short range domains did not have a well defined ordering as was reported for Nafion. HR-TEM on Ag-exchanged membranes confirmed the presence of the nanometer domains. A series of AFM studies (tapping mode) showed broad scale changes in the surface features with a change in the relative humidity.

Membrane electrode assemblies (MEA) were prepared from sulfonated endcapped polyarylenethioethersulfone copolymers (SPTES 50 and SPTES 70). The effects of the changes in the temperature of anode, cathode, degree of the humidification and pressure on the membrane performance will be discussed.