Highly Conductive Polyarylenethioethersulfone Electrolyte Membrane Fuel Cells

S. J. Rodrigues[1] , T.L. Reitz[1], T. D. Dang[2] and Z. Bai[3]

[1]Air Force Research Laboratory/PRPS, Energy Storage & Thermal Sciences Branch, 1950 Fifth St., Bldg 18
Wright-Patterson Air Force Base, OH 45433

[2]Air Force Research Laboratory/MLBP, Material and Manufacturing Directorate, 2941 P St., Bldg 654
Wright-Patterson Air Force Base, OH 45433

[3]University of Dayton Research Institute,
300 College Park Drive, Dayton OH 45469

High performance, sulfonated polyarylenethioethersulfone (SPTES) polymers have been developed for use in polymer electrolyte membranes for fuel cells. This high molecular weight polymer synthesized by a polycondensation route has a wholly aromatic backbone along with high sulfonic acid content providing for its high conductivity and robust mechanical properties. Bulky phenyl-based end-capping agents are incorporated into the system to maintain high water stability and retain high proton conductivity. Films with good mechanical properties were obtained by solvent casting. SPTES polymer systems with a range of sulfonation (50-100%) have been fabricated. Proton conductivity of up to 200 mS/cm at 65^{o}C and 100%RH has been achieved for a 50% SPTES membrane.

Membrane Electrode Assemblies (MEAs) fabricated using 50% SPTES electrolyte, incorporating conventional electrode application techniques have verified high proton mobility. In situ conductivities have exceeded 125 mS/cm, which is approximately 15% superior to Nafion™ membranes (110 mS/cm), measured under identical conditions. Calculated area specific resistance was 0.12 +/- 0.03 ohm-cm^2 for the SPTES MEA compared to 0.16 +/- 0.02 ohm-cm^2 for the Nafion™ MEA.

Catalyst utilization for SPTES MEAs using conventional electrode inks with perfluorinated binders was comparable to that exhibited by Nafion™. Estimates of hydrogen fuel permeability based upon measured open circuit voltage indicate that SPTES MEAs exhibit similar rates of fuel cross-over. Peak power density of 0.34 W/cm^2 @ 0.6 amp/cm^2 was obtained using SPTES membrane compared to 0.27 W/cm^2 @ 0.4 amps/cm^2 using Nafion™ membrane for the same conditions (80^{o}C, 55%RH, 1 atm, stoichiometry = 2 for H_2 and Air). Thermogravimetric analysis indicates that thermal stability of SPTES is comparable to Nafion™. The high temperature stability (up to 250^{o}C) and high proton conductivities of SPTES indicate potential application at high temperatures (100-120^{o}C) and have demonstrated reduced susceptibility to humidity.