ABSTRACT

Nanocomposite Polymer Electrolyte Membranes
for Fuel Cell Applications

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A possible green energy solution to the current fossil fuel energy crisis and overuse is the polymer electrolyte membrane fuel cell; but before it can be utilized extensively, new polymer electrolyte membranes must be developed. In this thesis nanocomposite polymer electrolyte membranes were developed.

TiO_2 nanotubes were synthesized for utilization as the nanocomposite. The effect of reaction time and starting particle size on the nanotubes was investigated. The optimum reaction time was three days. The greater the starting particle size, the larger the nanotube produced. The TiO_2 nanotubes were acid functionalized in order to increase proton conductivity using 1,3-propane sultone and 1,4-butane sultone as precursors. Acid functionalized nanotubes synthesized with 1,3-propane sultone showed the better proton conducting properties.

These nanotubes were then incorporated in various polymer electrolyte membranes. Well-studied PH-TA-Im membranes were used to investigate the effect of TiO_2 particles versus TiO_2 nanotubes on the membranes. Binary and ternary membranes based on Poly(1-vinyimidazole) and Polyvinylidene fluoride grafted with 1-vinylimidazole were synthesized using in-lab synthesized polymers. Unfunctionalized and functionalized nanotubes were incorporated into these membranes and the morphological, electrical, thermal and physical properties were studied. Proton conductivity of the order of 10^{-2} S/cm and thermal stability in excess of 200 °C was obtained.

Acid functionalized nanotubes were incorporated into a high temperature application polymer electrolyte membranes based on poly(2,5-benzimidazole) (ABPBI) and the effect of incorporation of a proton conductor versus traditional acid doping was studied. The morphological, physical, mechanical and thermal properties were studied and the membranes containing acid functionalized nanotubes were found to perform on par with acid doped membranes without suffering from thermal instability.

Keywords: Kerrilee A Stewart; Polymer Electrolyte Membrane Fuel Cells; Polymer Electrolytes; Nanocomposites; Renewable Energy.