A Novel Process to Fabricate Whole-Pore Bipolar Membranes for Fuel Cell: Method Improvements and Fuel Cell Performance Results

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The research presented represents the second-year effort on developing novel whole-pore bipolar membranes for H2/O2 fuel cells. During Year 1, bipolarity was created within the pores of Nafion membrane by carefully choosing the cations and manipulating Nafion pore properties. Best BPM were obtained with large self-assembling quaternary ammonium cations, such as Dodecyltrimethyl-ammonium and Cetyltrimethylammonium. Bipolarity was determined by measuring sodium ion exclusion after conversion. Second-year research goals were to: 1) demonstrate the performance of these new bipolar membranes in H2/O2 fuel cells, 2) improve/optimize synthesis method, 3) establish criteria for selecting cations, 4) create a deposition method to prepare next generation bipolar membranes Results from second year research indicated that bipolarity, created by self-assembling cations, was by-itself not sufficient in promoting water splitting in an H2/O2 fuel cell. To achieve water splitting, the bipolar membrane should not only exclude all ions from the membrane, it should also allow water to easily move around within the membrane pores. After testing various combinations of surfactants, polymers, and modifications to the synthesis approach, the required ideal bipolar membrane structure was obtained with polypyrrole incorporated into Nafion under carefully controlled conditions of monomer concentration, contact time, and polymerization. The results indicated that the performance of the pyrrole/Nafion bipolar membrane in a H2/O2 fuel cell were at par or exceed the performance of the benchmark Nafion membrane. The presence of Pyrrole inside the membrane and the unique pyrrole/Nafion interaction leading to the ideal bipolar structure were confirmed using X-ray Photoelectron Spectroscopy.

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