Using Broadband Electric Spectroscopy to Study Transport in Anion Exchange Membranes

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Introduction.
Alkali anion exchange membrane (AEM) fuel cells are being investigated to address current shortfalls of proton exchange membrane fuel cells, with the potential for direct use of methanol fuel and use of non-precious metal catalysts. Anion exchange membranes with properties that meet the demands of alkali fuel cell applications are not currently commercially available[1,2].Ionic conductivity and durability of AEMs has been shown to be heavily linked to humidity and temperature conditions.[3] Further understanding of the effects of hydration level and anion selection is needed to improve the performance of these materials.

In this work, randomly crosslinked copolymer AEMs were characterized under varied hydration levels and with hydroxide, carbonate and halide counter-ions. Varied methods of exchange to hydroxide form were investigated.

Experimental Methods.

The morphology of the membrane samples was studied with small and wide angle x-ray scattering at the Advanced Photon Source at Argonne National Laboratories. Humidity and temperature of the gas environment were controlled during scattering experiments. Levels of hydration were quantified using dynamic vapor sorption (DVS) apparatus. The effect of morphological differences in the samples on electrical properties was investigated through broadband electric spectroscopy (BES). The complex impedance spectra of membranes were measured in the frequency range from 10 mHz to 10 MHz under temperatures from -100 to 150 °C with a Novocontrol Alpha-A analyzer.[4] Membranes were tested under dry and hydrated conditions.

In-plane ionic conductivity measurements were collected using electrochemical impedance spectroscopy (EIS) with data from a multi-channel potentiostat under temperature and humidity control. These measurements were be used to determine the effects of water content and temperature on membrane performance. Conductivity measurements were performed on membranes both with halide and hydroxide counter-ions.

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