Comparing Membrane Properties for Redox Flow Batteries

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Membrane properties such as resistance to ionic transport and barrier properties to trans-membrane transport are of critical importance in redox flow batteries. In our recent work on Vanadium Redox Flow Batteries (VFRBs), we have achieved a situation in which membrane resistance is the largest source of voltage loss in the cell. However, cross-over through the membrane is still unacceptably high.

The membrane performance in the cell is largely determined by such factors as dehydration of the membrane in contact with concentrated electrolyte solutions and the uptake of solution electrolyte components into the membrane. Little of this information has been described in the literature. We recently began a systematic study of these properties and the membrane transport properties that result when the membrane is exposed to VFRB electrolytes. Our initial work focused on characterizing Nafion membranes. [1] Significant acid uptake and membrane dehydration is observed at acid concentrations in excess of ca. 0.5 M. As acid is imbibed, the conductivity of the membrane increases slightly until 2M. Above this concentration, the conductivity monotonically decreases. When vanadium ions are taken into the membrane without a high concentration of acid present, the membrane conductivity decreases dramatically. When 5M acid is present, this conductivity decrease is much less dramatic.

In this contribution, we begin to carry out comparative studies of the effects of membrane equivalent weight and chemistry. We have studied Nafion, '3M-ion' (a PFSA with a straight perfluorobutylsulfonate sidechain), SDAPP, a highly cross-linked sulfonated aromatic polymer and several anion exchange membranes. The uptake of acid and vanadium, conductivity, water content and transport rate of vanadium species have been probed.

In Figure 1, we show water and acid uptake results for 1100 EW Nafion, 825 EW 3.M-ion and 425 EW SDAPP. The same general trends that we previously reported are shown by all three membranes, with SDAPP taking the most acid and water into the sample at a given acid molarity. In Figure 2, we see that SDAPP exhibits a relatively high conductivity over much of the composition range. In the oral presentation, we will discuss these data as well as other transport phenomena in an attempt to elucidate critical influences on conductance and cross-over in VRFB membranes.

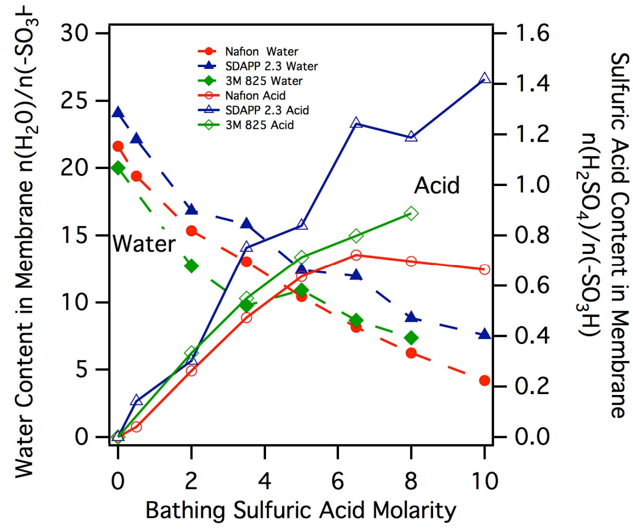

Figure 1. Uptake of acid and water as a function of the concentration of acid to which the membrane is exposed for 3 membranes.

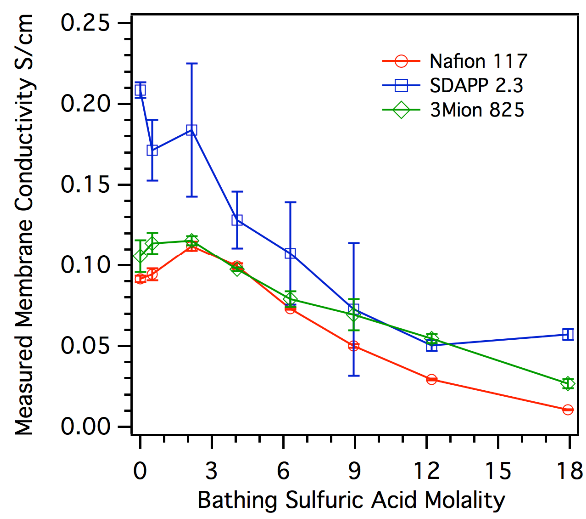

Figure 2. Membrane conductivity as a function of the concentration of acid to which the membrane is exposed for 3 membranes.

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1. Z. Tang, M. Bright and T. Zawodzinski, *submitted*.