Thermal and Mechanical Studies of the State of Water in Proton Conducting Fuel Cell Membranes

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For polymer electrolyte fuel cell technology to be more feasible for transportation, the desired operating temperature is 120°C. Though better CO tolerance and heat rejection can be realized, the proton conductivity in water dependant membranes is reduced. A core issue relates to the nature of proton transport and the role of water or other "proton transport facilitator" at such temperatures.

In this work, the thermodynamics of acid group hydration and mechanical properties were studied for different membranes (including Nafion and BPSH) and model systems (including an organic/inorganic composite (I/O) and a multiblock polymer (MB-150) both being developed at CAPI). Experiments were carried out with the membranes exposed to different activities of water corresponding to different levels of membrane hydration. Isopeistic sorption studies show a significantly greater uptake in water for the multiblock polymer as compared to the others (Fig. 1).

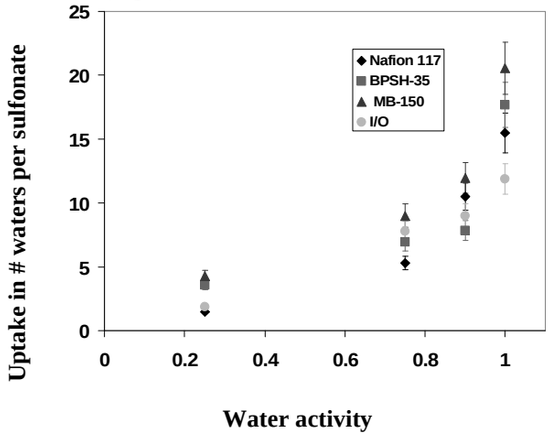

Fig. 1: Isopiestic sorption of vapor phase water (30°C) showing the increase in water uptake with increased water activity.

Differential scanning calorimetry (Fig. 2) and thermogravimetric analysis along with mass spectrometry were employed to couple the heat transfer and weight loss with respect to temperature while dynamic mechanical analysis was used to study thermal-mechanical properties, all to elucidate the state of water in the membranes. Understanding the state of water, the reason for it being in a particular state and the effect of water on the membrane under different conditions will help to direct membrane development or modification to operate a fuel cell at 120°C.

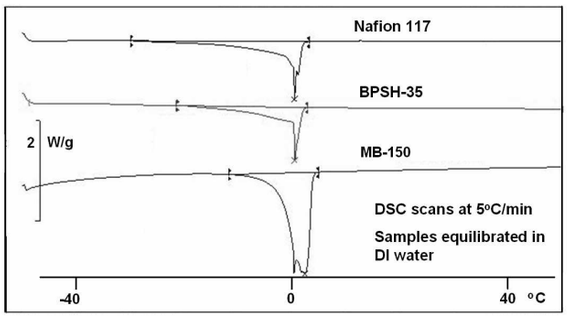

Fig. 2: DSC thermograms of PCFC membranes with MB-150 containing a significantly greater amount of "freezable" water as compared to Nafion 117 and BPSH-35

Ongoing work to relate the energetics of water sorption to different structural features of proton conducting polymer electrolytes will be reported.

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