

Characterization of Liquid Fuel Based Proton Exchange Membrane Fuel Cells

James M. Dolcimore, Kyle T. Clark, and
John B. Kerr*

Environmental Energy Technologies Division,
Lawrence Berkeley National Laboratory
One Cyclotron Rd, MS 62R0203, Berkeley, CA 94720
*Email: jbkerr@lbl.gov

The field of energy research, motivated by numerous economic and societal concerns, has produced a myriad of cleaner, cheaper, and more efficient energy alternatives. Proton exchange membrane fuel cells (PEMFCs) are amongst these energy conversion devices but wide application has been impeded by the difficulties involved in distribution and storage of hydrogen.

Promising alternative fuels have been identified, but they also require alternative catalysts and membranes. The interaction between the fuels, catalysts and membranes and the integration of these components into a complete and functional system requires additional study and testing.

This poster describes experiments designed to measure interactions between Nafion® N212 membranes (N212), fuels, and fuel products. Properties of the N212 such as conductivity, mechanical strength, thermal stability, and domain spacing were studied at various temperatures and relative humidity (RH) in the presence of fuels and their products.

Proton conductivity was measured using a membrane test system (MTS). The MTS measures through-plane conductivity using a two-point AC impedance technique while allowing for control of sample temperature and humidity¹. Figure 1 shows how the conductivity of the hydroxymethyl imidazole (ImOH) treated N212 membrane increases with increasing concentration.

Mechanical strength was determined by dynamic mechanical analysis (DMA) and a temperature control unit to maintain constant temperature. The DMA applied constant tension-type force deformations at three different frequencies through a range of RH values. Figure 2 shows the relative mechanical strength of an N212 control sample at different RH and the decrease in the stress response at each successive RH step.

Relative thermal stability of fuel treated membranes was obtained through thermogravimetric analysis (TGA). The TGA measures the change in mass over a range of temperatures from 50 - 600°C and provides information about relative thermal stability as well as some information about chemical interactions evident in endpoint analysis. Figure 3 shows the thermogravimetric curves for 2 ImOH treated N212 membranes of different concentrations against the N212 control. The addition of ImOH yielded an initial greater thermal stability followed by an increased volatilization rate.

Domain spacing was calculated through small-angle x-ray scattering (SAXS) experiments performed with the SAXS instrument at the Advanced Light Source (ALS) beam line 7.3.3 at Lawrence Berkeley National Laboratory. Intensity profiles in the q range of $0.02 \text{ \AA}^{-1} < q < 0.60 \text{ \AA}^{-1}$ were obtained at both ambient conditions (25°C, 30% RH) and at varying RH using a closed humidity control system. From the q values, distances can be easily calculated. Figure 3 shows how the distance of the hydrophilic and crystalline domains change at different RH. This can be compared to the MTS data to draw correlations between domain spacing and conductivity.

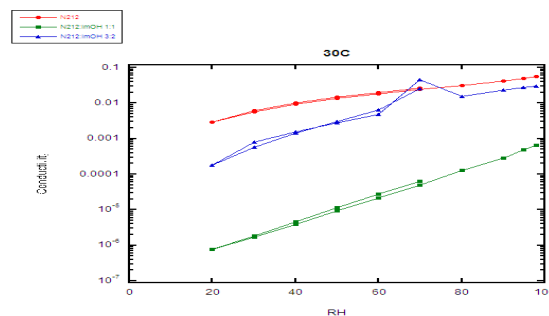
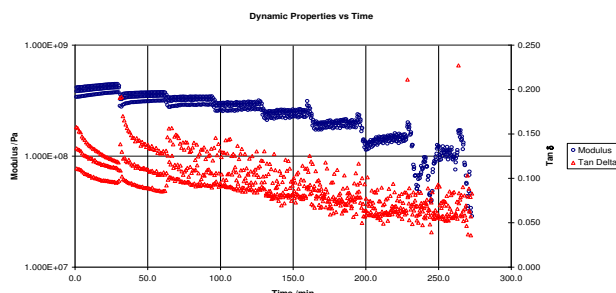


Figure 1. Changes to conductivity due to increasing ImOH concentration



3

Figure 2. Mechanical properties of N212 control sample at different RH

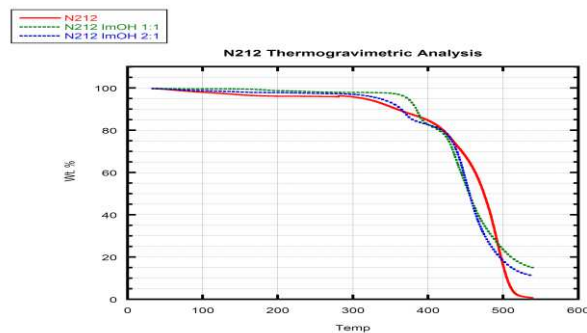


Figure 3. Relative thermal stability of increasing ImOH concentration

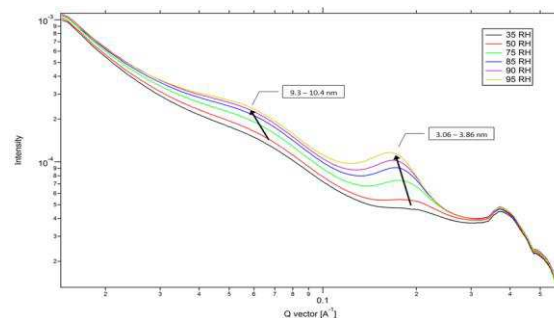


Figure 4. Domain spacing of N-ethylcarbazole treated membrane at different RH

References:

[1] Cooper, K. R. *J Electrochem. Soc.* **157** (11) B1731-B1739 (2010).

This material is based upon work supported as part of the Center for Electrocatalysis, Transport Phenomena, and Materials (CETM) for Innovative Energy Storage, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under Award Number DE-SC00001055 and under DOE Contract # DE-AC02-05CH11231.