In situ scanning transmission X-ray microscopy studies on the effects of relative humidity and temperature on MEA materials

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Proton exchange membrane (PEM) fuel cells have been viewed as a promising alternative energy source for automotive applications due to their cleaner emission profile and higher efficiencies. [1-2] However due to varying weather conditions around the world, PEM fuel cells must be able to start in a variety of different temperature and relative humidity conditions. One of the conditions of major concern are subzero conditions where ice formation inside the membrane electrode assembly (MEA) could potentially hinder or disable the startup of the fuel cell. [3-4]

Scanning transmission X-ray microscopy (STXM) is a powerful tool for characterizing fuel cell MEA components [5-11] as it provides chemical speciation via near edge X-ray absorption fine structure (NEXAFS) spectroscopy with spatial resolutions of 30 nm. In previous studies, combined C 1s and F 1s edge studies provide mapping and quantification of Pt, carbon support and ionomer in various MEA architectures. [10] Typically, ultramicrotomed thin sections (100-300 nm) of the MEA are studied under vacuum in the STXM chamber in which there is little to no control over the temperature and relative humidity. An environmental cell was designed to allow for studies of MEA components under controllable temperature and relative humidity conditions under atmospheric pressure.

We will present the design of the environmental cell which is quite challenging due to the stringent spatial restrictions of the STXM microscope. A Peltier device with suitable controls is used to establish the desired temperature in the environmental cell. Proportional mixing of dry and wet helium with feedback control is used for precise control of the relative humidity. The results of the deliquescence of salt particles will be summarized to show control over the relative humidity parameter. Lastly, we will present results on how water interacts with various MEA samples that have been placed inside the environmental cell at different temperature and relative humidity conditions.

References:

1. Y. Wang, K.S. Chen, J. Mishler, S.C. Cho and X.C. Adroher, *Applied Energies* 88 (2011) 981.
2. J.-H. Wee, *Renewable and Sustainable Energy Reviews* 11 (2007) 1720.
3. K. Jiao and X. Li, *Progress in Energy and Combustion Science* 37 (2011) 221.
4. S.G. Kandlikar and Z. Lu, *Journal of Fuel Cell Science and Technology* 6 (2009) 044001.
5. D. Bessarabov and A.P. Hitchcock, *Membrane Technology* 6 (2009) 6.
6. D. Susac, J. Wang, Z. Martin, A.P. Hitchcock, J. Stumper and D. Bessarabov, *ECS Transactions* 33 (2010) 391.
7. V. Berejnov, D. Susac, J. Stumper and A.P. Hitchcock, *ECS Transactions* 41 (2011) 395.
8. V. Berejnov, Z. Martin, M. West, S. Kundu, D. Bessarabov, J. Stumper, D. Susac and A.P. Hitchcock, *Physical Chemistry Chemical Physics* 14 (2012) 4835.
9. D. Susac, V. Berejnov, A.P. Hitchcock and J. Stumper, *ECS Transactions* 41 (2011) 629.
10. D. Susac, V. Berejnov, A.P. Hitchcock and J. Stumper, *ECS Transactions* 50 (2012) 405.
11. V. Berejnov, D. Susac, J. Stumper and A.P. Hitchcock, *ECS Transactions* 50 (2012) 361.