In Situ Observation of Membrane Degradation in PEM Fuel Cell via Raman Spectroscopy

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Raman spectroscopy is a powerful spectroscopic technique that can identify chemical bonding characteristics of molecules from inelastic scattering of photons. It is particularly useful for polymers. Micro Raman spectroscopy has been used to perform post mortem analysis of degraded polymer electrolyte in proton exchange membrane fuel cells [1, 2]. *In situ* micro Raman spectroscopy has been used to study water concentration profiles across membrane in a hydrogen pump cell [3] and in a fuel cell configuration [4, 5]. The authors report the application of micro Raman technique to observe fuel cell membrane degradation *in situ* during an open circuit voltage (OCV) hold experiment.

In the previous report, *in situ* micro Raman cell for hydrogen and oxygen fuel cell [4,5], the membrane is arranged horizontally with respect to the laser beam; when doing this, part of the electrode has to be removed or replaced with platinum grid. In this study, the author has devised an original edge-view *in situ* Raman cell (Fig. 1) that allows optical access to the membrane through the edge of a working polymer electrolyte fuel cell. In this configuration, r fuel cell electrodes can be preserved on both the cathode and the anode side. The hardware has been successfully developed and tested in this fuel cell configuration. For this report, an OCV hold test was conducted while collecting the Raman spectra of the perfluorosulfonic acid (PFSA) membrane.

Figure 2 and 3 show the evolution of Raman spectra at two different locations of the membrane during the OCV hold test up to 180 hours. A significant part of the membrane shows no degradation at all (as represented by Fig. 2), and a small region near the cathode electrode showed an accelerating trend of membrane decay (Fig. 3) as demonstrated by the weakening of the Raman peaks from 750 to 1100 cm^{-1} wave number. These peaks are associated with the side chain structure of the PFSA membrane [2]. The average fluorescence signal was also found to rise rapidly near the location of membrane degradation.

To our knowledge, this is the first time that the membrane degradation process was captured using an in situ Raman cell during fuel cell operation. The results indicate that the membrane degradation was mostly occurring in a localized region inside the membrane throughout the OCV hold experiment.

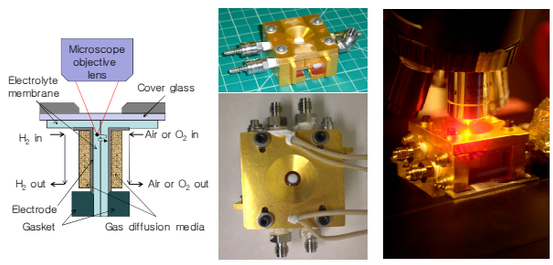

Figure 1. *In situ* Raman cell for membrane degradation study.

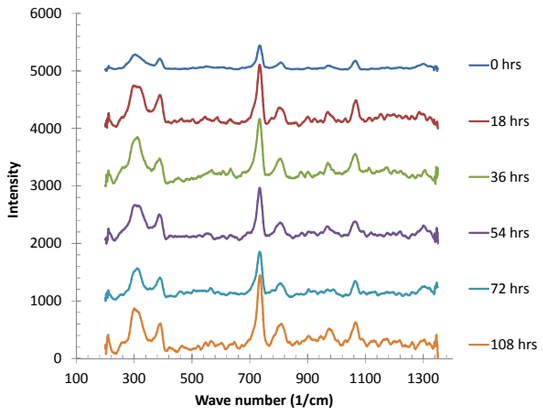

Figure 2. Evolution of Raman spectra in the PFSA membrane near the anode.

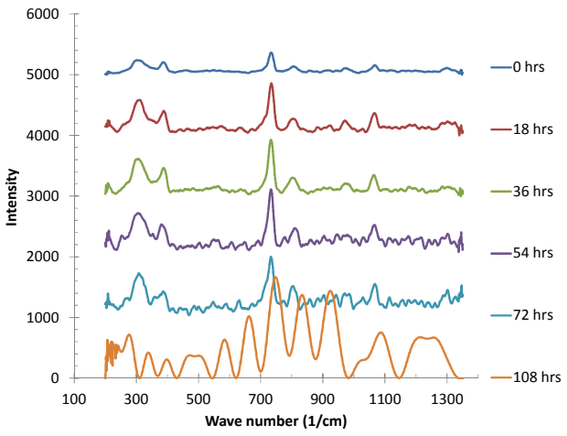

Figure 3. Evolution of Raman spectra at a location near the cathode of the membrane.

Acknowledgements:
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References:
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