Using the Technique of AC Impedance to Characterize Performance of Gas Diffusion Media in PEM Fuel Cells

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Gas diffusion media (GDM), a group of carbon based porous materials, play several important roles during operation of a polymer electrolyte membrane (PEM) fuel cells. They need to deliver reactant gas from flow fields to catalytic sites by through-plane and in-plane gas access, transfer product water away from catalytic sites to flow fields in over-saturated conditions, and maintain water within the membrane electrode assembly (MEA) in under-saturated conditions. In addition, they also need to conduct electrons as well as heat both through-plane and in-plane.

To better under the effect of GDM on fuel cell performance, it is necessary to separate the roles it plays relative to its many different functions. For example, under a given test condition, if a specific set of GDM enables better fuel cell performance than a different set, which attribute give rise to the improved performance? Is it better because the GDM imposes less gas transfer resistance, or less electronic resistance? Or because it retains water within the MEA, and therefore, lowers the ionic resistance of the MEA? In order to establish the important structure-property relationship of GDM and understand its influence on fuel cell performance, it is critical to answer those questions.

In our effort to acquire fundamental understanding of GDM, AC impedance was adapted as the technique that provides insights into separating different effects of GDM. AC impedance scans were performed within the frequency range of 8,000 to 0.1 Hz while a test cell was operated under various current densities. The real component of the impedance at high frequency represents physical phenomena such as electronic and ionic conduction that have a fast time constant. The resistance at low frequency reflects phenomena such as gas transfer or diffusion that have a slow time constant. An equivalent circuit model (as shown in Figure 1) was used to fit experiment AC impedance curves. R_1, R_2 and R_3 were extracted from the circuit model to represent electronic plus ionic resistance of the cell, kinetic resistance of the electrode, and gas transfer resistance of the GDM, respectively. Figure 2 represents the Nyquist plot of a typical set of AC impedance scan as well as the fitted result from the circuit model.

Specific examples will be presented to illustrate the usefulness of this technique, and to demonstrate the ability of this approach to illuminate the role of various functions of the GDM.

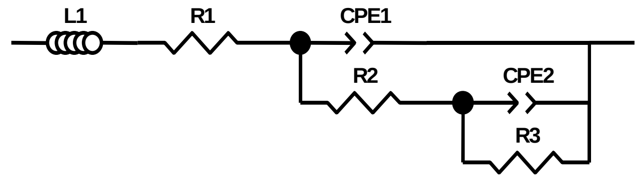

Figure 1. Equivalent circuit model used to fit experimental AC impedance results.

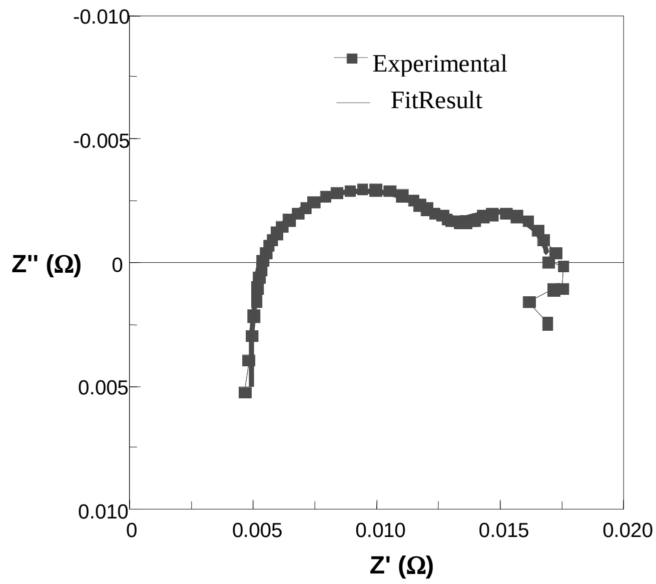

Figure 2. Nyquist plot of a typical set of AC impedance scan and the fitted result.

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