Using changes in PEM fuel cell performance on different oxidants as a diagnostic tool

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Introduction

The performance of a polymer-electrolyte membrane fuel cell may degrade during operation. Operating the fuel cell on different oxidants such as oxygen, air, and dilute mixtures of oxygen and nitrogen may assist in the process of accounting for losses. Applying mathematical models to such data may aid in the interpretation of the results.

Mathematical development

The air electrode of a PEM fuel cell can be adequately described by a model that includes Tafel oxygen reduction kinetics first order in oxygen partial pressure, Fick's law for oxygen transport in the catalyst layer, Ohm's law for ionic resistance, and Fick's law for diffusion from the gas flow fields.[1] Unfortunately, an analytical solution of this set of equations is impossible. However, analytical solutions are possible when either ionic resistance or diffusional losses in the catalyst layer can be neglected.[2] These analytical solutions may guide our thinking about how data should be plotted and how more sophisticated models should be used.

Results

Consideration of the analytical solutions suggests that a useful approach is to plot changes in oxygen gain (potential on oxygen minus potential on air) versus changes in air performance. Similar plots may be constructed for other combinations of oxidants. Figure 1 shows such a plot for the cases of changing mass-transfer resistance within and external to the catalyst layer. The analytical solutions cover the cases of varying rate constant, Ohmic resistance, catalyst-layer diffusion, and external diffusion. The four cases are qualitatively different. Therefore, changes in cell performance can be diagnosed using different mixtures of oxygen and nitrogen and compared to the model results to determine which of these major classes of polarization is responsible for the change.

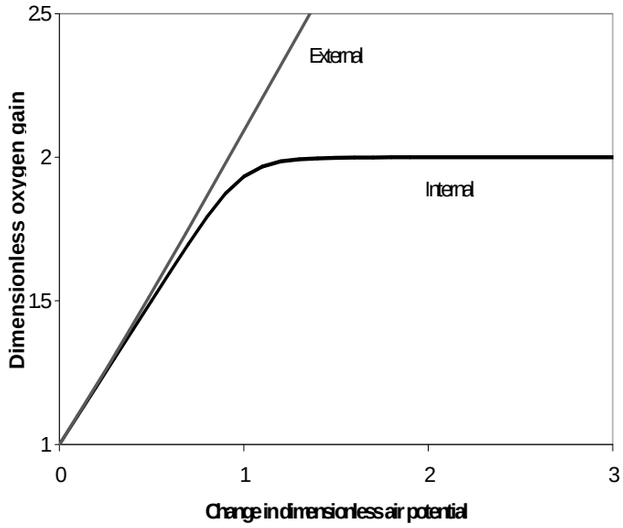

Figure 1: Plot of change in oxygen gain versus change in air performance.

References

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2. M. L. Perry, J. Newman, E. J. Cairns, "Mass transport in Gas-Diffusion Electrodes: A Diagnostic Tool for Fuel-Cells Cathodes", *J. Electrochem. Soc.*, **145**, 5 (1998).