# Effects of Long-Term PEMFC Operation on Gas Diffusion Layer and Membrane Electrode Assembly Physical Properties

David Wood[1,2], John Davey[1], Fernando Garzon[1], Plamen Atanassov[2], and Rodney Borup[1]

Los Alamos National Laboratory[1],
Electronic and Electrochemical Materials Group,
MST-11, Los Alamos, New Mexico 87545

University of New Mexico[2],
Department of Chemical & Nuclear Engineering
Albuquerque, New Mexico 87131

## Introduction

To adequately determine and quantify mechanisms of component degradation in Proton Exchange Membrane Fuel Cells (PEMFCs) operating over long periods, as in those required for commercial applications, key components must be well characterized during durability testing [1,2]. Stack reliability depends on knowing all physical aspects of the materials involved and the statistical variation from part to part and across the active area. When these physical properties change over the course of durability testing, the differences between fresh components and disassembled ones can be used to explain why performance deteriorates. Chemical degradation mechanisms in an operating environment are likely interconnected due to trace components that leach out of one component and subsequently affect another. For this reason, each key component must be well understood in terms of how it degrades as a stand-alone material in order to understand its influence on the other components.

A key feature of novel components for PEMFCs that operate at 80°C or less, have highly humidified gas feed streams, or maintain high current density (≥1 A/cm$^2$), is how they interact with and transport liquid water [3]. Liquid water transport is a balance between surface chemistry and pore volume distribution. The objective of this work is to begin an initial, comprehensive characterization of wetting behavior and pore volume parameters, with time-dependence, for various Gas Diffusion Layer (GDL) materials and Membrane Electrode Assemblies (MEAs). Materials will be examined thoroughly before and after testing. However, it is not always convenient to obtain 1000's of hours of durability testing for a prospective component material, so a method to simulate an operating PEMFC environment over accelerated time frames is needed. To assist in this pursuit, accelerated life chambers were constructed to subject components to a simulated, weakly acidic liquid environment in an isolated state with total control over impurity exposure. With these chambers, leachate analysis and component degradation studies can be performed. The ultimate goal is to correlate physical property changes from disassembled durability cells with the leachate chamber data.

## Experimental

Various methods for measuring water transport properties have been investigated including sessile drop contact angle, Wilhelmy plate contact angle, Washburn absorption, breakthrough (hydro-head) pressure, and liquid permeability. Pore-size distribution and specific surface area were examined with different techniques such as capillary flow porometry, Hg/$H_2O$ intrusion porosimetry, and BET adsorption. Furthermore, X-ray mapping with Energy Dispersive Spectroscopy (EDS) and X-ray Fluorescence Spectroscopy (XFS) may be used to determine changes in elemental composition at surfaces or through cross-sections. These methods are particularly useful for PTFE distributions in various GDLs and catalyst-layer component distribution in MEAs.

The accelerated life chambers have been used to systematically study affects of various components of the rather aggressive PEMFC operating environment, which consist of oxygen/hydrogen, liquid water, pH, potential, current flow, and operating temperature. Figure 1 shows a picture of an accelerated life chamber, which is a hollow cylinder of pure PTFE equipped with an inert heating coil, gas sparging capability, optional pressurization, and optional fluid recirculation. There is also a sampling port for obtaining component leachate samples over time. Figure 2 shows preliminary data for hydrophobized Toray TGP-H graphite-fiber paper (17 wt% FEP) subjected only to 60/80°C pure DI-water for 450 hours. A decreasing relative hydrophobicity trend is seen, most of which occurs within the first 100 hours of exposure.

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## References

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**Figure 1.** Inert chambers for accelerated life testing and isolated component leachate analysis.

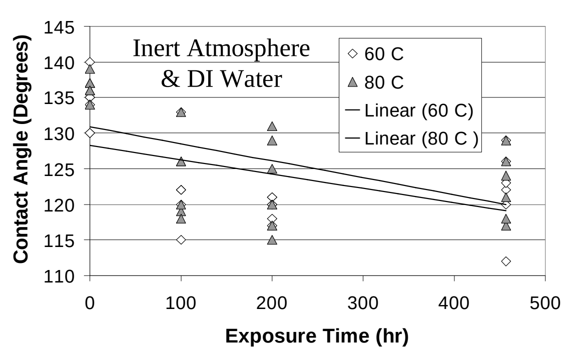


**Figure 2.** Sessile drop contact angle vs. heated DI-water exposure time for Toray TGP-H GDLs (17 wt% FEP).