Fluorinated Ionomers and Membranes for PEM Fuel Cells

Steven Hamrock
3M Company

Author Proton exchange membrane fuel cells (PEMFC's), using hydrogen fuel, are being evaluated as a clean energy source for a variety of applications, including transportation, back-up power, material handling (fork lifts) and providing power for remote locations. While many technical achievements have been made over the last few years, and system and material costs have been substantially decreased, wide spread adoption and commercialization of these systems requires further improvements in power output, efficiency, durability and cost. One barrier to PEMFC commercialization is the requirement for external gas humidification to maintain high membrane conductivity and durability. This humidification requirement results in increased system cost and parasitic power loss. Without adequate humidification, fuel cell membranes can dry out, causing increased cell resistance and performance loss, and accelerated chemical degradation.

To meet the industry's conductivity and durability requirements without external stack humidification, improved ionomer membranes are required. Membranes based on low equivalent weight ionomers have been shown to meet conductivity targets, but these materials typically have poor mechanical properties and high water solubility which compromise durability.

This tutorial presentation will describe the critical properties of Perfluorinated Sulfonic Acid (PFSA) membranes in fuel cells and new fluorinated ionomers being developed to address deficiencies in these membranes. At 3M, we are developing new perfluorinated and partially fluorinated ionomers with multiple protogenic hydrogen atoms on each side-chain (Multi Acid Side Chain, or MASC polymers) to address these needs. We have shown that membranes made from these polymers can provide a better combination of durability and conductivity at low water content when compared to the corresponding PFSA membranes. An example is the Perfluoro Imide Acid (PFIA), shown in Figure 1. This new ionomer has been synthesized in high yield, and new nanofiber-composite membranes have been prepared from it and evaluated in fuel cells.

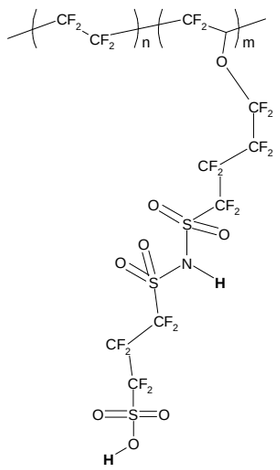

Figure 1. Per Fluoro Imide Acid (PFIA)