Characterization and Performance of Catalyst Layers prepared by Inkjet Printing Technology

Madhu S. Saha, Mickey Tam, Scott McDermid, Darija Susac, Jürgen Stumper

Automotive Fuel Cell Cooperation Corp.
9000 Glenlyon Parkway, Burnaby BC V5J 5J8, CANADA

Polymer electrolyte membrane fuel cells (PEMFCs) continue to attract considerable attention as power generator for transportation and portable applications due to their high energy density, rapid start-up characteristic, and high energy conversion efficiency [1]. However, the technology must be made further cost competitive with other energy conversion and power generation devices. Understanding the relationship between structure, properties, and performance is an essential prerequisite in finding a cost effective materials in PEMFC. The main challenges in PEMFC research arise in the catalyst layers because they are complex heterogeneous multiphase structures. Catalyst materials and catalyst layers need to be designed to generate high rates of desired reactions while minimizing the amount of catalyst required in order to reach the required levels of power output. In addressing these issues, a few requirements need to be considered: (1) large interface between the polymer electrolyte and catalyst, (2) efficient transport of protons generated at the anode and consumed at the cathode at the reaction spots, (3) easy transport of reactant or product gases and removal of condensed water, and (4) continuous electronic current passage between the reaction spots and the massive current collector [3]. The overall catalyst layer performance depends on all these critical factors and is therefore essential to identify the composite structures and operation conditions which provide the best balance between them.

Most of the known fabrication procedures like spraying, painting, rolling, screen printing, etc., lack the desired degree of precision and there is not much control over the final structure of the fabricated catalyst layer [4]. Recently, a newer catalyst deposition technique based on inkjet printing permits the generation of droplets at pico-litre resolution and offers fine control of the position at which the ink can be dispensed [5,6].

In this presentation, we have employed inkjet printing technique for the fabrication of catalyst coated membrane (CCM) as this technique offers the potential of providing a high degree of precision and accuracy. Microscopic examination of the prepared CCM as well as interface and the elemental map analysis were carried out to get the structural relationship, adhesiveness of the catalyst with electrolyte and the distribution of catalysts. Scanning transmission X-ray microscopy was used to determine the ionomer distribution withing the catalyst layer. The cathode catalyst layer performance was evaluated by electrochemical methods in a single-cell PEMFC.

References:

1. K. Kordesch, G. Simander, Fuel Cells and their Applications. VCH, Germany, 1996, 73.
2. R. Borup, et al., Chem. Rev. 107 (2007) 1.
3. Z. Xie, C. Song, D.P. Wilkinson, and J. Zhang, Catalyst Layers and Fabrication, in a book on Proton exchange membrane fuel cells: materials properties and performance, Taylor and Francis, D. P. Wilkinson, et al., Eds. (2009), Page 61-104.
4. M. Eikerling, A.A. Kornyshev, A.M. Kuznetsov, J. Ulstrup, S. Walbran, J. Phys. Chem. B 105 (2001) 3646.
5. M.S. Saha, D. Malevich, E.Halliop, J.G. Pharoah, B.A. Peppley, K. Karan, J. Electrochem. Soc. 158 (2011) B562.
6. S. Towne, V. Viswanathan, J. Holbery, P. Rieke; J. Power Sources, 171 (2007) 575.