New conceptual zeolitic direct methanol micro fuel cell

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Through miniaturization, microelectronics had given us greater mobility and global inter-connectivity. The need to power the increasingly more sophisticated handheld devices placed a great demand for lightweight power unit that have larger power capacity and usage time to allow the enjoyment of the full benefit of a mobile broadband communication. The micro fuel cell offers a clean and efficient solution to this problem. It has the advantage of high specific and volumetric energy densities, longer life cycle, zero-recharging time and greater flexibility. Methanol is the preferred fuel for micro fuel cells, because of stringent size and weight requirements for these portable devices. The current direct methanol fuel cell (DMFC) employs polymer proton-exchange membrane. Typical perfluorinated sulfonic membranes (e.g., Nafion®) suffer from swelling and loss of mechanical strengths in the presence of methanol leading to a deterioration of membrane structure. Methanol crossover from the anode to the cathode is a major problem that results in catalyst poisoning, hot spots, low open circuit potential and poor fuel cell performance. This can be improved by chemical treatment, modification of polymer chain and addition of copolymers. Sulfonated arylene main chain polymers such as polysulfones or polyetherketones (e.g., SPEEK), borosiloxane polymers and commercial Acidplex® displayed good tolerance for methanol. However, improvements in membrane resistance come at the expense of lower proton conductivity.

Several inorganic-organic hybrid materials such as zirconium hydrogen phosphate immobilized in SPEEK, crosslinked polyethylene oxide doped with acidic moities and pore-filling electrolyte membrane on porous inorganic substrates as well as zeolite-doped Nafion also showed promising results. Recent work by the authors [1] demonstrated that ZSM-5 zeolite membrane is both an effective proton conductor and methanol barrier. Studies suggest that the zeolite membrane structure and chemistry can be further engineered to obtain higher proton flux without jeopardizing the micromembrane’s ability to prevent fuel crossover. A micro fuel cell was assembled from ZSM-5 micromembrane and tested using hydrogen and methanol fuels and compared with micro fuel cell using traditional Nafion 117 membrane. The results show that zeolite is a promising membrane material for micro fuel cell.

[1] Hydrogen and Proton Transport Properties of Nanoporous Zeolite Micromembranes, J. L. H. Chau, A. Y. L. Leung, M. B. Shing, K. L. Yeung and C. M. Chan, Nano Science and Technology : Novel Structures and Phenomena, 2nd Croucher ASI on Nano Science and Technology, HKUST, Hong Kong. Taylor and Francis, 2003. p. 228-232