A step towards the real world application of polymer electrolyte fuel cells: Enhancing the durability

Mohamed R. Berber, PhD

WPI-I^{2}CNER, Kyushu University
(Fuel cell division)

Fuel cells, in particular polymer electrolyte membrane fuel cells (PEMFC) are receiving a great deal of attention because its practical use in transportation and commercial sectors. PEMFC that works without humidification at high temperatures became a market requirement because it offers several advantages over the currently available FCs (Nafion-based FCs). For example, the problem of water management becomes unnecessary; leaching of the electrodes decreases and the activity of Pt based-electrode improves.

The most severe bottleneck that prevents PEMFC from reaching its full technical potential lies in the undesirably low-performance. The heart of the issue is the polymer electrolyte membrane and the electrocatalyst (structure design and composition). To meet these two objectives, there is a need for new advanced materials to overcome the problems associated with the membrane and the electrocatalyst, such as the low-conductivity, the low durability, the low thermal stability, the leaching of the dopants, and the limited operational temperature range.

Phosphoric acid-doped polybenzimidazole membrane (PA-PBI) seems so far the most successful candidate to achieve a high performance PEMFC. During the doping process, the first two PA molecules absorbed by the PBI membrane forming a salt by protonation of imine N group at the imidazole ring (Figure 1). Further PA molecules are incorporated on the membrane as a free acid. However PA-PBI system exhibits high proton conductivity when PBI polymer retains large amount of free PA. Thus, a leaching process of the membrane free PA molecules can be a problematic issue. The recent studies have revealed that leaching of liquid phosphoric acid (PA) from both polymer electrolyte membrane and catalyst layers causes inhomogeneous PA distribution that results in deterioration of PEMFC performance during the long-term operation[J. Power Sources 189, 943 (2009);J. Power Sources 195, 1007 (2010)].

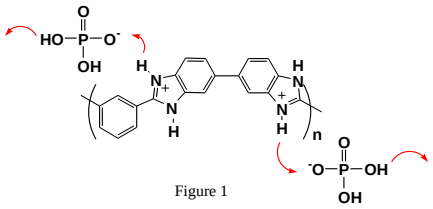

Figure 1

Recently, I offered a new design for the membrane electrode assembly (MEA). This novel MEA showed a remarkable high durability (single cell test: >400,000 cycling) together with a high power density at 120˚C under a non-humidified condition (Figure 2) *(Berber et al, Nature, SRep Vol. 3, pp.1764, 2013)*. My present MEA opens the door for the "real world" application of PEMFC.

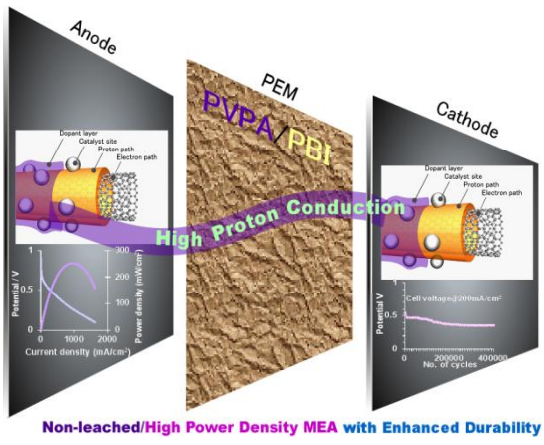

Figure 2