

Development of Wide-temperature PEFC Operative Under no External Humidification

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Fuel cell is key technology to convert hydrogen energy into electric power quite efficiently. Especially, polymer electrolyte fuel cell (PEFC) is promising candidate for the energy source of car, portable electronic device, and house. One of the ultimate targets of PEFC technology is the operation of the cell under dry condition in wide temperature range (0 – 200 °C). However, current technology allow us to use PEFC only below 80 °C in highly humidified condition since the proton transfer in the polyelectrolyte is limited in this condition. For this limitation, current PEFC system required the cooling device together with humidifier, resulting in the increasing of the device size and cost. Simplest idea to overcome the limitation is to replace the polyelectrolyte material, Nafion[®], to better polymer.

Polybenzimidazole (**PBI**, Fig. 1) is known to show proton conduction after acid doping and recognized as a promising polyelectrolyte for PEFC. The advantage of the PBI as a electrolyte is the PBI exhibits a excellent proton transfer under dry condition at higher temperature (100 °C~). To realize the **PBI**-based PEFC, we need to develop a electrocatalyst containing **PBI** as an ionomer.

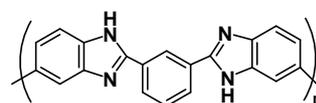


Fig. 1 Chemical structure of PBI.

We have reported **PBI** adsorbed onto the surface of carbon nanotubes (CNTs) and acts as the good dispersant of CNTs [1]. CNTs have been emerged as a better conductive supporting material for catalyst nanoparticle than conventional material such as carbon black due to their excellent electron conductivity, better electrochemical durability and fibrous structure. By taking the advantage of uniform wrapping of **PBI** on CNTs surface, we utilized this composite (CNT/**PBI**) as a novel carbon supporting materials for the loading of platinum (Pt) nanoparticles to fabricate a electrocatalyst for PEFC. As the result, the CNTs/**PBI** show better efficiency of Pt loading than that of pristine CNTs due to the coordination between Pt ion and **PBI** (Fig. 2), where CNT, **PBI** and Pt as a electron path, proton path and reaction site, respectively. The obtained electrocatalyst (CNT/**PBI**/Pt) shows excellent Pt utilization efficiency mainly due to the formation of ideal interfacial structure around Pt [2,3]. We

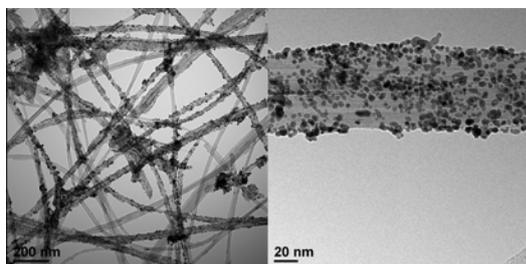


Fig. 2 TEM images of CNT/**PBI**/Pt.

fabricated the PEFC membrane electrode assembly (MEA) using phosphoric acid-doped **PBI** and CNT/**PBI**/Pt as a electrolyte membrane and electrocatalyst, respectively, and measured the fuel cell performance using hydrogen and air as fuels [4]. Surprisingly, our PEFC showed better performance from room temperature to 120 °C without any external humidification than conventional Nafion-based PEFC. We assumed the excellent performance to the ideal nano- and micro-structure provided by the

CNT/**PBI**/Pt in the electrocatalyst layer [5].

[1] *Adv. Funct. Mater.* **18**, 1776-1782 (2008). [2] *Small* **5**, 735-740 (2009). [3] *Carbon* **47**, 3227-3232 (2009). [4] *J. Mater. Chem.* **21**, 1187-1190 (2011). [5] *Unpublished data*