

## Durability of Pt Catalysts Supported on Ordered Mesoporous Carbon for Proton Exchange Membrane Fuel Cells

Nam-In Kim<sup>a</sup>, Min-Ji Yang<sup>a</sup>, Sung-Hwa Cho<sup>a</sup>, Jun-Young Park<sup>a</sup>, Han-Shin Choi<sup>b</sup>, Sang Hoon Joo<sup>c,\*</sup> and Kyungjung Kwon<sup>d,\*</sup>

<sup>a</sup> Green Energy Research Institute, Department of Nanotechnology and Advanced Materials Engineering, Sejong University, Gunja-dong, Gwangjin-gu, Seoul, 143-747, Republic of Korea

<sup>b</sup> Korea institute of rare metals, Korea institute of industrial technology, Incheon 404-254, Republic of Korea

<sup>c</sup> School of Nano-Bioscience and Chemical Engineering, Ulsan National Institute of Science and Technology (UNIST), 50 UNIST-gil, Ulsan 689-798, Republic of Korea

<sup>d</sup> Department of Energy & Mineral Resources Engineering, Sejong University, Gunja-dong, Gwangjin-gu, Seoul, 143-747, Republic of Korea

Proton exchange membrane fuel cells (PEMFCs) have been investigated for useful power source of electric vehicles because of their high power density and fast startup. However, PEMFCs have many issues for commercialization such as low oxygen reduction reaction (ORR) activity and unsatisfactory durability of Pt catalysts. Therefore, a study on changes in ORR kinetics during long-term operation of catalysts will be very significant for the development of Pt catalysts.

Hence, we synthesized a series (4 types) of ordered mesoporous carbon (OMC) using ordered mesoporous silica as a template and the corresponding OMC-supported Pt catalysts (Pt/OMC) were synthesized finally. Then, their physicochemical properties were confirmed by using various analytic techniques such as SEM, TEM, BET, XRD and so on.

For electrochemical characterizations, a rotating disk electrode system was adopted with an Ag/AgCl reference electrode and a Pt counter electrode in 0.1M HClO<sub>4</sub> electrolyte. An accelerated durability test (ADT) where cyclic voltammetry with purging oxygen gas in the potential range of 0.6 – 1.1 V versus reversible hydrogen electrode (RHE) was conducted at a scan rate of 50 mV s<sup>-1</sup> for 1000 cycles was used for simulating long-term operation of cathode catalysts. ORR activity was measured by linear sweep voltammetry from 1.1 to 0.3 V at a scan rate of 10 mV s<sup>-1</sup> and the ORR activity before and after the ADT was compared to evaluate the degradation of Pt catalysts.

Fig. 1 shows representative TEM images of OMC and Pt/OMC. In this case, the OMC has a structure where carbon nanorods of which surface area is larger than 1000 m<sup>2</sup> g<sup>-1</sup> are connected to each other. The Pt/OMC has a Pt particle size around 3 nm. Fig. 2 shows a change in cyclic voltammogram of Pt/OMC before and after the ADT. The electrochemical surface area (ECSA) of Pt nanoparticles, which can be evaluated by measuring an area of hydrogen adsorption/desorption peak, is much reduced after the ADT. In addition to the change in ECSA of Pt, a change in ORR activity was also measured. Changes in ECSA and ORR activity depending on the structure and properties of OMC will be analyzed in conjunction with morphology change and compared with a commercial Pt/C.

- J. Y. Cheon, C. Ahn, D. J. You, C. Pak, S. H. Hur, J. Kim, S. H. Joo, *J. Mater. Chem. A*, **1**, 1270 (2013).
- C. Liu, M. Chen, C. Du, J. Zhang, G. Yin, P. Shi, Y. Sun, *Inter. J. Electrochem. Science*, **7**, 10592 (2012).
- S. H. Liu, F. S. Zheng, J. R. Wu, *Appl. Catal. B*, **108-109**, 81 (2011)
- S. H. Liu, C. C. Chiang, M. T. Wu, S. B. Liu, *Inter. J. Hydrogen Energy*, **35**, 8149 (2010).
- K. Kwon, S. Jin, C. Pak, H. Chang, S. H. Joo, H. I. Lee, J. H. Kim, J. M. Kim, *Catal. Today*, **164**, 186 (2011).
- K. Kwon, Y. J. Sa, J. Y. Cheon, S. H. Joo, *Langmuir*, **28**, 991 (2012).

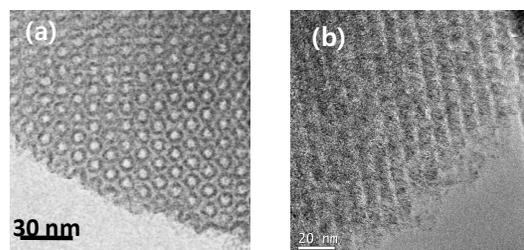


Fig. 1. TEM images of (a) OMC support and (b) Pt/OMC.

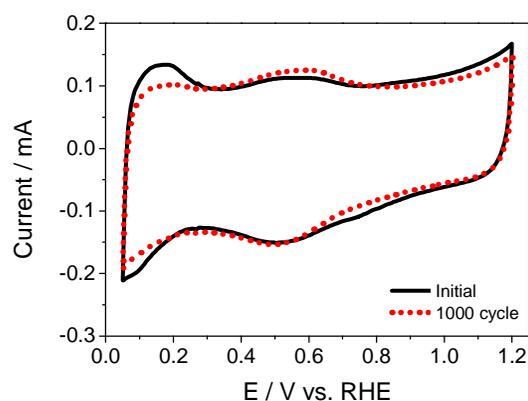


Fig. 2. Comparison of cyclic voltammograms of Pt/OMC before and after the ADT.

- J. Jhang, K. Sasaki, E. Sutter, R. R. Adzic, *Science*, **315**, 220 (2007).
- S. H. Joo, S. J. Choi, I. Oh, J. Kwak, Z. Liu, O. Terasaki, R. Ryoo, *Nature*, **412**, 169 (2001).
- R. Ryoo, S. H. Joo, M. Kruk, M. Jaroniec, *Adv. Mater.*, **13**, 677 (2001).