

Controlled Growth of Pt-on-Pd Bimetallic Core-shell Nanoparticles and Their Electrocatalytic Activity for Oxygen Reduction Reaction

Chun-Jern Pan (潘俊仁)¹, Ming-Yao Cheng (鄭銘堯)¹, Bing-Joe Hwang (黃炳照)¹,
Ishii Hirofumi (石井啟文)², Jeyaraman Jeyakanthan (桀肯特)², and Jyh-Fu Lee (李志甫)²

¹Department of Chemical Engineering,
National Taiwan University of Science & Technology, Taipei, Taiwan
²National Synchrotron Radiation Research Center, Hsinchu, Taiwan

Proton exchange membrane fuel cell (PEMFC) is one of the promising candidates as an efficient and pollution-free power source for automotive, portable and stationary application [1-2]. Since the direct conversion from the chemical energy to electrical energy with fuel cells, Carnot limitation is not applicable [3]. However, several critical issues have been addressed for commercialization purpose. One of the important academic issues is slow kinetics of the oxygen reduction reaction (ORR) with Pt catalyst, which causes power losses and overpotential significantly [4, 5]. Further, the high cost of Pt is another barrier for real practice. Among the materials under investigation worldwide, Pt-Pd is one of the most candidates for ORR.

The nanoarchitecture of Pt on Pd is able to alter the accordingly electrocatalytic activity. For example, Pt monolayer on Pd core-shell nanoparticle [6] and Pt-Pd bimetallic nanodendrites [7], both exhibit superior performance for ORR reaction. Therefore, control of nanoarchitecture, even down to atomic level, is critical. Here we try to develop the strategy to achieve the goal with the aid of XAS analysis for atomic engineering of Pt on Pd nanoparticles.

resolve in the spectra). The FT EXAFS spectra at Pt L_{III}-edge for the samples with various amount of Pt stacking are shown in Fig. 2. The bond length of Pt-Pd and Pt-Pt are 2.75 and 2.77 Å, respectively. The structural information of Pt on Pd clusters can be extracted from the fitting of EXAFS data.

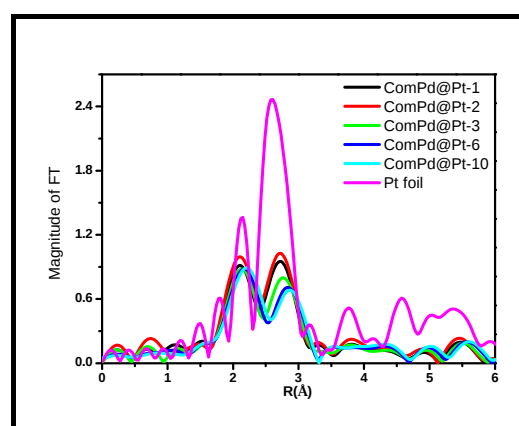


Fig. 2: FT EXAFS spectra at Pt L_{III}-edge

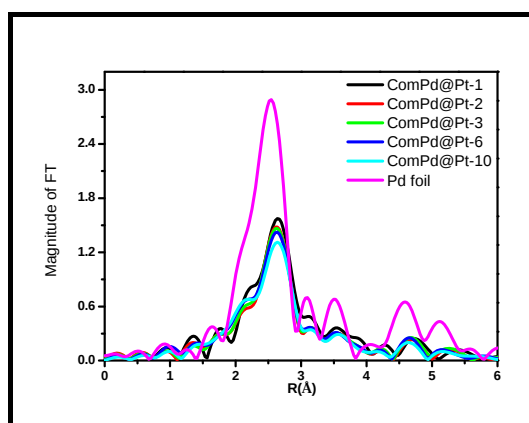


Fig. 1: FT EXAFS spectra at Pd K-edge

Here, the commercially available Pd/C was firstly employed as the core material. The size of Pd nanoparticles is around 3 nm, and then the platinum atoms were deposited on the surface of Pd nanoparticles of various controlled conditions

The FT EXAFS spectra at Pd K-edge for the Pt@Pd core-shell-like nanoparticles with various conditions for the controlled Pt deposition on Pd surface are shown in Fig. 1. It is clearly shown the bond length of the Pd-Pd and Pd-Pt are 2.70 and 2.75 Å, respectively (did not

References

- [1] C. Song, *Catal. Today* **77**, 17 (2002).
- [2] M. Winter and R. Brodd, *Chem. Rev.* **104**, 4245 (2004).
- [3] T. He, E. Kreidler, L. Xiong, and E. Ding, *J. Power sources* **165**, 87 (2007).
- [4] J. X. Wang, N. M. Markovic, and R. R. Adzic, *J. Phys. Chem. B.* **108**, 4127 (2004).
- [5] B. J. Hwang, S. M. S. Kumar, C. H. Chen, Monalisa, M. Y. Cheng, D. G. Liu, and J. F. Lee, *J. Phys. Chem. C* **112**, 2370 (2008).
- [6] J. Zhang, M. B. Vukmirovic, Y. Xu, M. Mavrikakis, and R. R. Adzic, *Angew. Chem. Int. Ed.* **44**, 2132 (2005).
- [7] B. Lim, M. Jiang, P. H. C. Camargo, E. C. Cho, J. Tao, X. Lu, and Y. Xia, *Science* **332**, 1302 (2009).