Design and preparation of Pt nanoclusters on polybenzoimidazole-wrapped carbon nanotubes and their use in energy conversion

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1. Introduction

The commercialization of proton exchange membrane fuel cells (PEFC) can help to mitigate global warming and reduce our dependence on fossil fuels. The efficient cathodic electrocatalysts for oxygen reduction are largely unavailable, so fundamental progress in the design of these catalysts is highly needed. Recently, Pt ions and nanoclusters provide a promising approach to reduce Pt usage and enhance Pt catalysis toward oxygen reduction reaction [1,2].

In this study, we designed and fabricated Pt nanoclusters that were deposited on the surfaces of polymer-wrapped carbon nanotubes. We used multi-walled carbon nanotubes (MWNTs) and PBI as the carbon support and the polymer, respectively, because they have unique physical and chemical properties when using them in the PEFC electrocatalysts as previousl reported [3]. The use of polyelectrolyte as an anchoring unit is advantageous in view of the practical applications in the PEFCs.

2. Experimental

PBI/MWNT composites were prepared according to the previous method, then dispersed them in water by sonication, to which a K_2PtCl_4 or H_2PtCl_6 aqueous solution was added. After stirring, the obtained composite solution was washed by water to remove any excess Pt ions. Then, the solid product was collected by filtration, which was dried under vacuum. The obtained material (MWNT/PBI/$Pt_{nanocluster}$) was characterized using the X-ray photoelectron spectroscopy (XPS), thermogravimetric analyses (TGA), scanning transmission electron microscope (STEM) and electrochemical measurements.

3. Results and discussion

The XPS analysis of the product revealed that the valency of immobilized Pt on the MWNT/PBI is different when using K_2PtCl_4 or H_2PtCl_6 as a Pt source. Figure 1 shows liner sweep voltammograms (LSVs) for the MWNT/PBI/$Pt_{nanocluster}$ made from K_2PtCl_4 (blue line) and H_2PtCl_6 (red line) in 0.1 M $HClO_4$ solutions saturated with oxygen. The results indicated that the valency of Pt affected the oxygen reduction reaction .

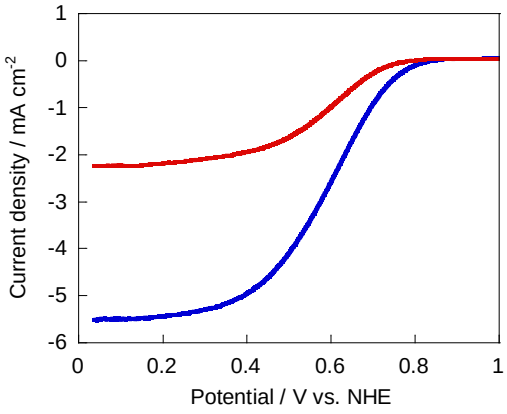

Figure 1. LSVs for MWNT/PBI/$Pt_{nanocluster}$ made from K_2PtCl_4 (blue line) and H_2PtCl_6 (red line) in 0.1 M $HClO_4$ saturated with dissolved oxygen, obtained at a scan rate of 10 mV s^{-1}. Rotation rate =1500 r.p.m.

[1] K. Kamiya, R. Kamai, K. Hashimoto, S. Nakanishi, *Nat. Commun*. **5**, art. no. 5040 (2014)

[2] K. Yamamoto, T. Imaoka,W-J. Chun, O. Enoki, H. Katoh, M. Takenaga, A. Sonoi, *Nat. Chem*. **1**, 397 (2009).

[3] I. H. Hafez, M. R. Berber, T. Fujigaya, N. Nakashima, *Sci. Rep*. **4**, art. no. 6295 (2014).