Fabrication of Polyelectolyte-wrapped Carbon Nanotube Composites for Fuel Cell Electrocatalyst

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Carbon nanotubes (CNTs) are attractive in materials science due to their outstanding electronic and mechanical properties. Among wide range of applications of carbon nanotubes metal nanoparticle/CNTs hybrid is an attractive output especially for fuel cell electrocatalyst due to the large surface area, remarkable electric conductivity and excellent electrochemical durability of CNTs. In this study, Pt has been immobilized on CNTs and applied to the fuel cell application. Up to date, perfluoro sulfonicacid polymers such as Nafion have been used as a polyelectrolyte for polymer electrolyte fuel cell (PEFC) and the development of the Nafion-based electrocatalyst is extensively studied. However, the cost and the mechanical weakness of Nafion require the alternative polyelectrolyte. Sulfonated polymers such as sulfonated polyimide (SPI) is the promising candidate for the polyelectrolyte in the PEFC in next generation and proposed to use them as the membrane of the cell. To realize the PEFC based on the polyelectrolyte membrane, the same polyelectrolyte materials are required to be added into the electrocatalyst layer as an ionic path. We employed polyelectrolytes poly [(2,2-benzidinedisulfonicacid)-*alt*-(1,4,5,8-naphthalenetetracarboxyicdianhydride)] (BDSA-NTD), around multi-walled carbon nanotubes (MWNTs) with a few nanometer thickness and attached a platinum nanoparticle (Pt) onto the polyelectrolyte layer to fabricate the electrocatalyst, where MWNT and Pt serve as electron path and reaction site, respectively(Figure 1). For polyelectrolytes, Pt nanoparticles with narrow distribution were homogeneously dispersed on the polymer–wrapped MWNTs (Figure 2). Indeed, a high-resolution TEM image of the MWNT/SPI/Pt clearly shows close contact between the Pt particles and the MWNTs surface, together with the Pt exposure over the SPI layer. The average particle diameter of the Pt on MWNT/SPI/Pt was calculated to be 2.58 ± 0.42 nm. An accessible surface area on Pt for the fuel cells, the so called electrochemically active surface area (ECSA) was evaluated using cyclic voltammetry. The characteristic peaks in the negative region (from -0.2 to 0.1 V vs.Ag/AgCl) attributable to atomic hydrogen adsorption and desorption on the Pt nanoparticle surfaces are apparently detected, which state the electronic communication between Pt and MWNTs. The ECSA was calculated using the following formula,

$$ECSA = Q_H/(210 \times \text{Pt loading on electrode})$$

Where QH is the charges exchanged during the electroadsorption of H on Pt. The amount of Pt loaded on the electrode was determined by the amount of composite solutions casted on the electrodes. ECSA were calculated to be 35.6 m^2/g of Pt, respectively. These results provide useful information for the design and fabrication of triple phase interface structures of fuel cell electrode catalysts with high efficient performance.

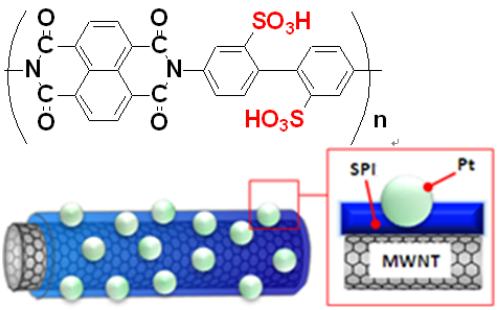

Figure.1. Illustration of the MWNT/SPI/Pt.

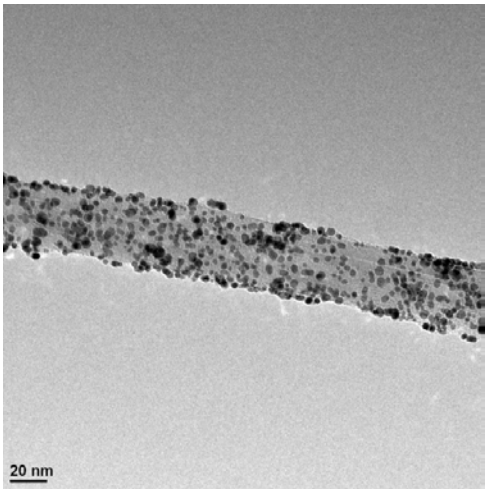

Figure.2. TEM images of the MWNT/SPI/Pt. Pt nanoparticles are loaded homogeneously on the SPI wrapped MWNTs

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