Physical Properties of Pt-Cr/C Nanoparticles Synthesized by Thermal Decomposition and Ethylene Glycol Method as Investigated by Small-Angle X-ray Scattering

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In order to achieve a high mass activity of Pt-based alloys in the Oxygen Reduction Reaction (ORR) of Direct Methanol Fuel Cell (DMFC), it is crucial to have a high dispersion of Pt-based alloys catalysts on the high surface area carbon support. However, the mass activity is not only influenced by the high catalyst dispersion. Another physical properties of catalysts, such as particle size and its uniformity on the carbon support are also having a great contribution.

Carbon supported Pt-Cr catalysts were chosen for the ORR in fuel cell devices. Several studies have reported the advantages of these catalysts instead of another bimetallic catalysts, such as Pt-Co, Pt-Fe, Pt-Ni, etc. Pt-Cr is not only contributing of high mass activity for ORR, but also providing good stability and high tolerance for methanol oxidation at the cathode side.

Several drawbacks of catalysts preparation method have been reported. Usually, bimetallic catalysts were synthesized by the impregnation of the second metal precursor on the Pt/C, then followed by heating at the temperature higher than 700 ^{o}C under inert or reductive gas, in order to form bimetallic alloys. However, such a higher temperature treatment will lead to the difficulties in controlling the alloys composition, particle size and uniformity of bimetallic alloys. Temperature lower than 200 ^{o}C was used in another methods, such as carbonyl complex process, and water-oil microemulsion. It will suppres alloys sintering and result in smaller particle size. However, the lacking of stabilizer in those methods will contribute to the difficulty in controlling their alloys composition.

In our recent progress, we have succesfully synthesized Pt-Ru catalyst by employing the Ethylene Glycol (EG) method. In this method, ethylene glycol will be oxidized to glycolic acid or glycolate anion, depending on the pH medium. The glycolate anion formed acts as a stabilizer for the metallic colloids, hence the resulting metal particle size is controlled via the synthesis solution pH. In our current progress, we have proposed an alternative way to synthesize Pt-Cr catalysts, so called a thermal decomposition method. In this method, Cr have a tendency to bind with the —OOC from the oleic acid, while Pt to the —NH_2 from the oleylamine. Pt-Cr particles are immideately capped and electrostatically stabilized against oxidation by the presence of both stabilizers, oleic acid and oleylamine.

In this study, carbon supported Pt-Cr catalysts were synthesized by using both methods, EG and thermal decomposition method, and their physical properties were investigated by using Small-Angle X-ray Scaterring (SAXS). This kind of study can not be conducted by using our strength and experience in X-ray Absorption. Complementary data from the SAXS, XRD, and TEM are consolidating each other, were used to investigate the physical properties of the Pt-Cr/C.

Fig. 1 shows not only the interaction between the carbon support and catalyst, but also the interaction between its metal-metal catalyst.

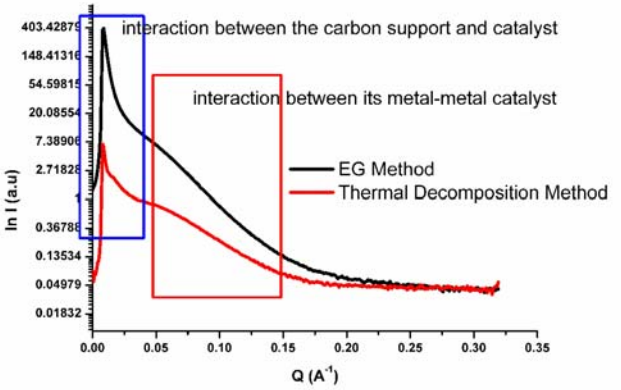

Figure 1. SAXS patterns of Pt-Cr/C synthesized by EG and thermal decomposition method, at X-ray energy 9.0 keV.

The data in fig. 1 can be fitted with the Guiner rule by only focusing on the interaction between its metal-metal catalyst. The results shows that the particle size of Pt-Cr/C synthesized by EG (3.61 nm) is larger than Pt-Cr/C synthesized by thermal decomposition (3.04 nm), and both catalysts shows a spherical shape as satisfiied the Guiner rule, as can be seen in the fig. 2.

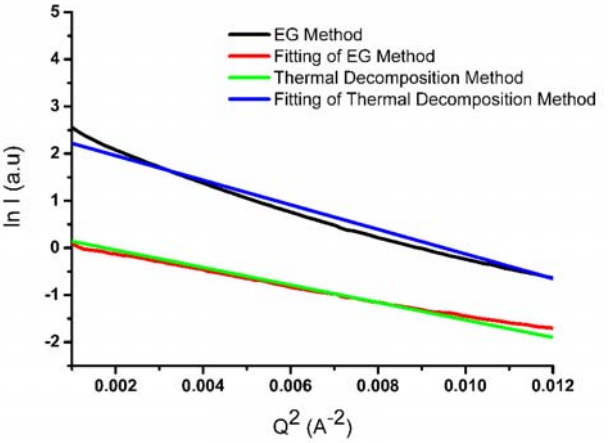

Figure 2. Fitting result of figure 1, by focusing on the interaction between its metal-metal catalyst, at X-ray energy 9.0 keV.