Synthesis of Core-shell Co@Pt/C Electrocatalyst and Effects of stabilizer and pH on its Performance

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For the purpose of reducing the cost of PEMFC, it is important to develop catalysts with low content Pt but high ORR performance. The core-shell nanoparticle catalysts such as M@Pt (M=Cu, Co, Ni, Fe, etc.) for fuel cells have attracted intense attention owing to their shape-dependent properties and the improvement of the ORR activity.

Co@Pt/C core-shell catalysts were synthesized by a two-step chemical reduction method followed by the heat treatment in H_2 and N_2 mixture at 300 ℃ . High Resolution-TEM (HR-TEM), XRD and XPS techniques are used to characterize the nano-structured catalysts. The electrocatalytic performance, kinetic characteristics and durability of catalysts are measured by cyclic voltammetry (CV) and linear sweep voltammetry (LSV) technologies.
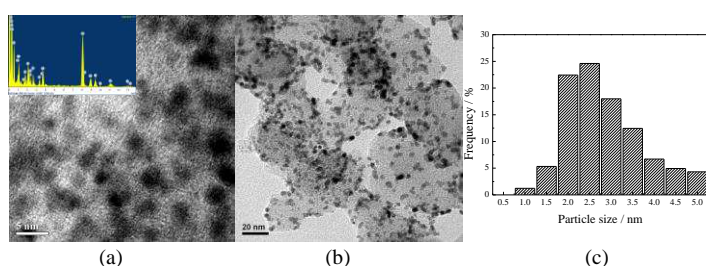

(a) (b) (c)

Fig. 1. HRTEM, EDX (a), TEM (b) and particles distribution (c) images of Co@Pt (1:3)/C electrocatalyst

The TEM results (Fig.1) show that the core-shell structure of Co@Pt/C is formed and the average particle size is about 3 nm. The different brightness indicates that there exists dissimilar element on the carbon support. It is seen that metal particles were uniformly dispersed on the surface of carbon and there is no obvious aggregation of Pt particles.

Form the results of electrochemical characterization, it was found that the formation of core-shell structure favors for the utilization of Pt.

The improved mass activity of platinum might be due to the effect of the geometric effect which induced by the formation of core-shell structure. This allows a larger number of catalytically active sites to be present on the accessible surface of the particles as cobalt played as contained in the underlying core.

Form the results of kinetic characteristics, it can be inferred Co@Pt/C catalyst proceeds by an approximately four-electron pathway in acid solution, through which molecular oxygen is directly reduced to water.
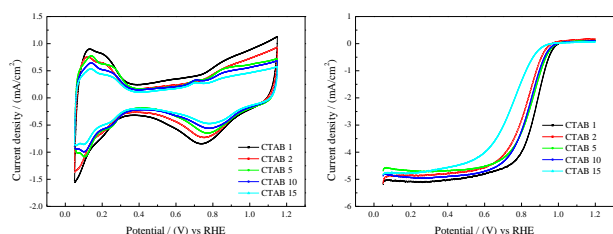

Fig.2. The effects of CTAB dosage in preparing process on the performance of the Co@Pt/C catalyst. (a) CV curves of the catalyst; (b) LSV curves of the as-prepared catalyst
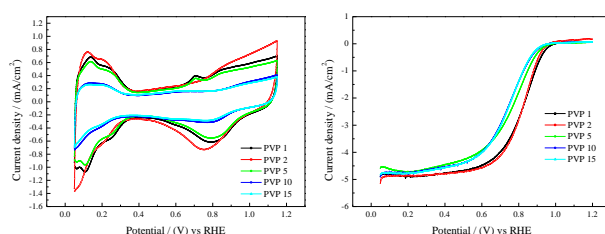

Fig.3. The effects of PVP dosages in preparing process on the performance of Co@Pt/C catalyst. (a) CV curves of the catalyst; (b) LSV curves of the as-prepared catalyst

The effects of stabilizer and pH on catalyst performance were also investigated (Fig. 2 and Fig. 3). It was found that the types and dosages of stabilizer significantly affected the performance of the as-prepared catalysts. When the CATB was employed for the preparation, the more proper dosage (mass) was approximately equal to that of total metal mass (Pt+Co). For PVP, it was about 2 times of the total metal mass. Additionally, it seemed that the usage of the CATB was more efficiently to improve the performance of the Co@Pt/C catalyst.
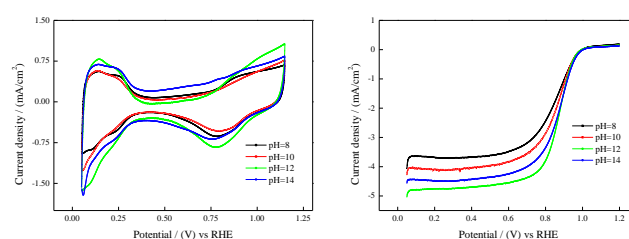

Fig.4. The effects of pH in preparing process on the performance of Co@Pt/C catalyst. (a) CV curves of the catalyst; (b) LSV curves of the as-prepared catalyst

The pH in the preparing process is one of the key factors which affect the catalyst performance. In our work, the effects of pH on the performance were also studied. It can be found from the results (Fig.4) that the pH value at 12 was helpful to inform the high performance catalyst.

The performance of the membrane electrode assembly (MEA) prepared by as-prepared as the cathode catalyst in a single fuel cell was also tested. A 130 hours life time test for the single cell was operated to evaluate the durability.

During the whole aging test, the decay of the cell is slow and inconspicuous. It infers that the durability of Co@Pt core shell structure catalyst is superior to that of alloys.

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