

Prussian blue cubes dispersed on carbon as a non-precious oxygen reduction catalyst for alkaline fuel cell

Jakkid Sanetuntikul and Sangaraju Shanmugam*

Department of Energy Systems Engineering, Daegu Gyeongbuk Institute of Science & Technology, 50-1, Sang-Ri, Hyeonpung-Myeon, Dalseong-Gun, Daegu, Republic of Korea, 711-873
sangarajus@dgist.ac.kr*

Platinum (Pt) is the most commonly used catalyst for PEMFCs due to its high activity. Pt nanoparticles dispersed on the carbon is usually used as an electrocatalyst for ORR; however, the high cost of Pt is one of the most technical limitations in the commercialization of fuel cell technology. So, the design of high-performance cathode catalyst is to reduce the cost of fuel cell catalysts. Recently, research efforts have been devoted to decrease the cost of Pt electrocatalysts by adopting innovative approaches, there has been considerable interest to develop non-precious metal catalyst for oxygen reduction reaction; however, the ORR activities of non-precious metal catalysts are still on less competitive compared to Pt. The development of simple and efficient method to fabricate based catalyst is required.

In this study, we introduce a simple method to fabricate Prussian blue cubes supported on carbon (PBC/C) by a single step route using a single step precursor. The non-precious catalyst was prepared by pyrolysis under autogenic pressure, and then the product was treated with concentrated HCl to dissolve oxide, and to form PBC/C. The samples were characterized by using SEM, TEM, XRD techniques. The electrochemical oxygen reduction properties were studied using CV, RDE and RDE. The ORR activity of PBC/C displayed good performance as a non-precious metal catalyst.

The electron microscope (SEM and TEM) studies confirmed that the products obtained after acid treatment the formation of cubes on the carbon surface. The TEM image of PBC/C shows that the diameter approximately around 200 nm (Fig.1). The XRD patterns can be assigned to $\text{Fe}_{2.962}\text{O}_4$ (JCPDS 98-008-2440) phase structure. The as-prepared samples were treated in concentrated HCl for 24 h to remove iron oxide. After acid treatment, PB cubes were crystallized on carbon (JCPDS 01-073-0687) (Fig.2a).

The electrocatalytic ORR performance of PBC/C was carried out by rotating disc electrode (RDE) voltammetry and RDE traces were recorded in O_2 saturated 0.1 M KOH at a scan rate of 10 mV/s over an electrode rotation rate of 1600 rpm. The PBC/C performs well for ORR in alkaline medium as evidenced in Fig. 2b, a significant oxygen reduction current can be seen for all rotating speed. To verify the ORR catalytic pathways of these catalysts, RRDE measurements were carried out to focus on the formation of H_2O_2 during the ORR process. The produced H_2O_2 for the PB/C composite catalyst is below 10% and the corresponding electron transfer number is calculated to ~ 3.8 over the potential range of 0.2-0.8 V, which is well consistent with the result obtained from the K-L plots.

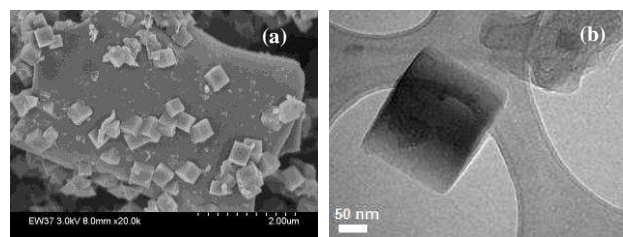


Fig 1. (a) SEM (b) TEM images of PBC/C.

The durability of PB/C and Pt/C catalysts toward ORR was evaluated by chronoamperometric response at 0.6V and results are presented in Fig. 2(d). The durability studies suggest that the decay of ORR current was prominent for Pt/C than PB/C, which indicates a better durability of PB/C for O_2 reduction in alkaline solution. The high selectivity of PBC/C toward ORR makes it a very promising electrocatalyst for alkaline fuel cell. This novel synthesis method may be extended to many other kind of research for wide application including energy storage, electrocatalyst and biosensor.

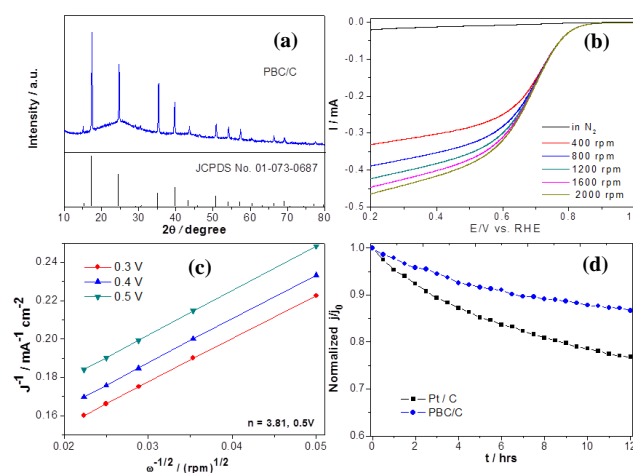


Fig 2. (a) XRD pattern of PBC/C, (b) RDE traces of PBC/C electrode in aqueous 0.1 M KOH saturated with O_2 at different rotation rates. (c) The corresponding Koutecky-Levich plots at different potentials, and (d) chronoamperometric responses of PBC/C and Pt/C catalyst in O_2 -saturated 0.1M KOH.

References

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