

Pt Catalysts Supported on High Surface Area Graphene Composites for PEFCs

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Graphene is a single-atomic-layer-thick graphite sheet, which can provide the thinnest catalyst support for Pt catalyst nanoparticles. In addition, graphene has extremely high electronic conductivity and high surface area. All of these make the graphene as an ideal candidate for Pt catalyst support in polymer electrolyte fuel cells (PEFCs).

In our recent work, nanosized carbon blacks were functionalized with hydrophilic groups (i.e. $-\text{SO}_3\text{H}$). Subsequently, graphene sheet / nanocarbon composites (GSNC) were prepared. Graphene composites made using this approach has achieved high specific surface area $1860 \text{ m}^2/\text{g}$. The nano-sized functionalized carbon black particles attach onto the surface of the graphene sheets and serve as spacers to separate and support the neighboring sheets, resulting in high surface area in the catalyst. In this work, we developed Pt catalysts using two kinds of the nano-structured graphene composites as the supports. Pt catalysts (Pt/GSNC) were prepared using graphene sheet synthesized with different loadings of functionalized carbon blacks. The synthesized catalysts were characterized using BET and RDE for their catalytic performance in oxygen reduction reaction (ORR).

The surface area and oxygen reduction reaction of Pt/GSNC catalyst with different amounts of functionalized carbon blacks (FCBs), from 0.2% to 3%, are studied. The BET Surface Area of Pt/GSNC catalyst with different functionalized carbon blacks (from 0.2% to 3%) is $268 \text{ m}^2/\text{g}$, $197 \text{ m}^2/\text{g}$, $468 \text{ m}^2/\text{g}$, $308 \text{ m}^2/\text{g}$ and $369 \text{ m}^2/\text{g}$, respectively. The mass activity change according to catalyst surface area is shown in Fig 1. It seems that the Pt/GSNC performance did reach the max performance with the suitable graphene surface area. This may be due to the pore structure of the graphene which in turn, affects the mass transfer of Pt complex ions during the preparation of Pt/GSNC catalyst.

Since nano-sized functionalized carbon black particles attach onto the surface of the graphene sheets and serve as spacers to separate and support the neighboring sheets, this GSNC may have much bigger pore size which facilitates the mass transfer of Pt complex ions and makes the Pt nanoparticles on the graphene surface dispersed well. In addition, the bigger pore size will benefit the mass transfer and Nafion ionomer particles penetrated into the pore to form good proton conduction path inside the catalyst layer. Corrosion test results show the significant improvement on corrosion resistance from the use of graphene in comparison with the commercial catalyst (shown in Fig 2). The high conductivity of graphene has shown significantly improvement on kinetic performance (i.e. low current density). The MEA characterization of the developed Pt/GSNC catalysts is undergoing and the results will be reported soon.

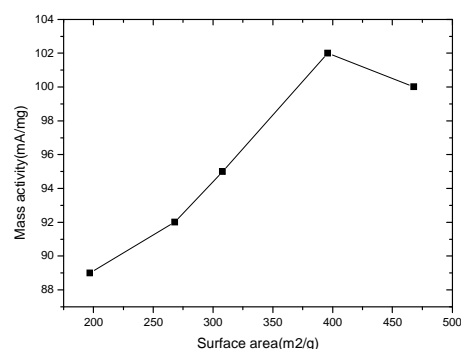


Figure 1. The mass activity change according to catalyst surface area.

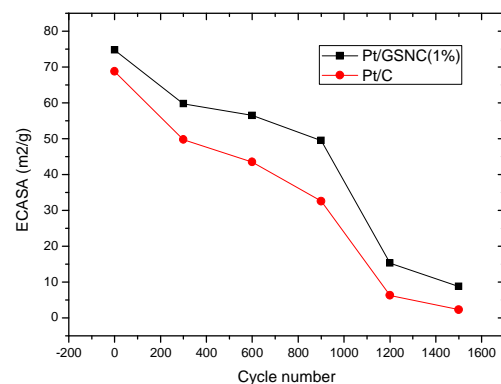


Figure 2. Corrosion test results of Pt/GSNC (with 1% FCB) compared with commercial catalyst.