Abstract #532, 223rd ECS Meeting, © 2013 The Electrochemical Society

Development of PtRu/3D Graphene Foam Bimetallic Catalysts for Methanol Oxidation Reaction in Energy Storage

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Bimetallic nanoparticles-assembly systems have gained interest in the development of catalysts for energy storage in recent years. PtRu catalysts exhibit a superior activity in methanol oxidation reaction (MOR).[1] Graphene foam is a 3D multilayer freestanding graphene film which is a promising material using for sensors and energy storage.[2] 3D graphene foam has particularly a high surface area due to its porous structure providing a cost-effective route to store massive amounts of energy. In this study, synthesis of graphene foam with PtRu nanoparticles producing the catalyst for methanol oxidation reaction was investigated.

Fig. 1 showed the cyclic voltammograms for methanol oxidation over PtRu catalyst with Vulcan XC-72R carbon and 3D graphene foam in a solution of 0.5 M H_2SO_4 and 1 M CH_3OH. The range of scanned potential was between -0.24 V to + 1.2 V for sixteen cycles with a scan rate of 0.1 V/s. The reported CV profiles in Fig. 1 were recorded for the 16th cycle at 298 ^oK. The methanol oxidation current density served as an indicator for estimating the activity of catalysts under practical conditions. The current density of PtRu/3D graphene foam was higher than PtRu/C and pure PtRu, suggesting that the mix of 3D graphene foam with PtRu was a superior promotion of MOR for alloy catalysts. The addition of the carbon supporting materials resulted in significant PtRu particles segregation and therefore increased surface area and improved the current density of the catalysts especially for the 3D graphene foam.

The current density of PtRu/3D graphene foam was nearly quintuple as high as that of PtRu/C as shown in Fig. 1. The increased number of active adsorption sites and the larger surface area accelerated the transport rate of the reactive species resulting in the enhanced catalytic activity. Fig. 2 showed the sustainability performance of PtRu catalyst with Vulcan XC-72R carbon and 3D graphene foam. Both current densities of PtRu/C and PtRu catalysts approached zero after 900 cycles, indicating the poor sustainability of these electrocatalysts. However, the current density of PtRu/3D graphene foam catalyst remained at 80 mA cm^{-2} after 300 cycles.

Fig. 3 showed the STEM images for the PtRu, PtRu/C, and PtRu/3D graphene foam catalysts. PtRu particles with rather uniform dispersions were formed on the catalysts depending on the different carbon supported materials. In the STEM images of PtRu, an aggregation of particles was observed. This was because pure PtRu particles were not separated without carbon supported materials. Additionally, it appeared that the PtRu particles were more uniformly well-dispersed with Vulcan XC-72 carbon and 3D graphene foam. The availability of more surface area of the carbon supported materials facilitated better dispersion of the PtRu particles.

In summary, the PtRu catalyst with 3D graphene foam showed good current density and sustainability for the methanol oxidation compared with those of the pure PtRu nanoparticles.

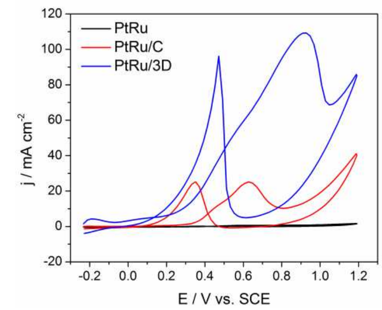

Fig. 1. The cyclic voltammograms for methanol oxidation over PtRu catalysts with different carbon based materials in a solution of 0.5 M H_2SO_4 and 1 M CH_3OH.

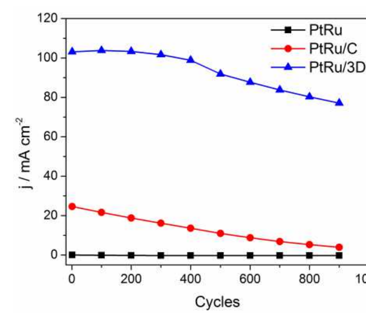

Fig. 2. The sustainability performance of PtRu catalysts with different carbon based materials.

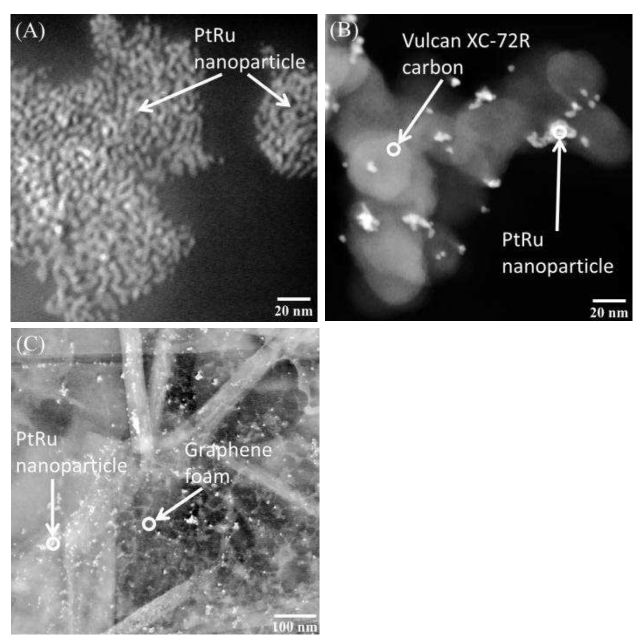

Fig. 3. STEM images of catalysts: (A) PtRu (B) PtRu/ Vulcan XC-72R carbon (C) PtRu/3D Graphene foam.

Acknowledgments
This study is supported by the DOD-Air Force Office of Scientific Research—MURI 2011-microfabrication.

References

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