PtRu/CuNWs catalysts for methanol oxidation reaction in direct methanol fuel cells

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Direct methanol fuel cells (DMFCs) are an attractive alternative to hydrogen-fueled proton exchange fuel cells for powering portable electronic devices because of their high energy density and ease of fuel transportation and storage. While nearly zero overpotential is observed for hydrogen oxidation reaction in acid, large overpotential exists even on the state-of-the-art PtRu/C MOR catalyst.[1] Therefore, developing catalysts with high MOR activity is of great importance.

MOR is known to be a structure sensitive reaction with Pt(110) facet showing the highest specific activity among low index surfaces.[2] One-dimensional (1D) nanostructures such as nanowires, nanotubes and nanorods often have the preferential exposure of certain facets which will enhance the MOR activity.[3]. Studies have shown that platinum nanotubes (PtNTs) have higher MOR specific activity than platinum nanoparticles supported on carbon (Pt/C)[4], which might be attributed to the exposure of (110) facets of PtNTs. However, it remains unclear whether 1D PtRu nanostructures have higher MOR activity.

In our work, we synthesized one-dimensional PtRu nanotubes (PtRuNTs) and PtRu coated Cu nanowires (PtRu/CuNWs) via complete or partial galvanic displacement of CuNWs by Pt and Ru precursors. By varying the Pt and Ru precursor ratio, PtRuNTs and PtRu/CuNWs with different Pt:Ru ratio were obtained. Their MOR activities were evaluated by cyclic voltammetry using rotating disk electrodes.

The PtRu compositional effect on MOR has been widely explored. One study reported that the optimal alloying composition is 50 at. % Pt[5], while another showed that PtRu alloys with a surface composition of 90 at. % Pt has the highest activity[6]. By varying the Pt:Ru ratio, we achieved higher specific and mass activity on PtRu/CuNWs compared with a commercial MOR catalyst PtRu/C (HiSPEC® 12100), as shown in Figure 1. The thin coating of PtRu on CuNWs greatly reduced the amount of precious metals used, enabling the enhancement of mass activity.

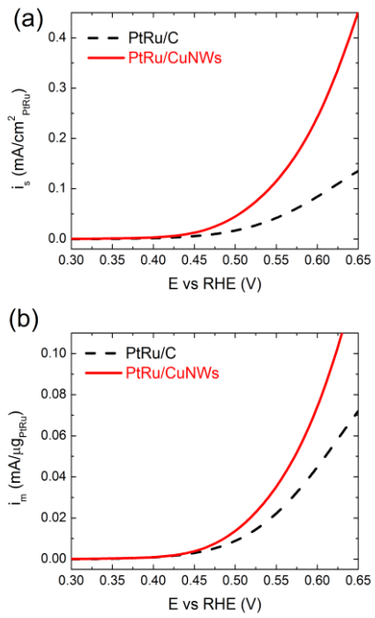

Figure 1. Comparison of (a) specific activity (b) mass activity of MOR between PtRu/CuNWs and a commercial MOR catalyst PtRu/C (HiSPEC® 12100), testing condition: 0.1 M $HClO_4$, 1 M CH_3OH, Ar, scanning rate 5 mV/s.

References

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