Durable Multi-component Anode Catalyst for Use in DMFC

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Introduction

Direct methanol fuel cell (DMFC) converts the chemical energy of fuel into electricity and is a promising sustainable power source for the future. Liquid methanol fuel of DMFC is easy to handle and refill, both are essential features needed for mobile applications. Furthermore, the high energy density (~6.1 kWh/kg, 4.8 Wh/L) is also an obvious advantage of DMFC over pressurized hydrogen (~1 Wh/kg, 3 Wh/L) and lithium batteries in mobile applications. At present, catalyst accounts for more than half the cost of MEA in DMFC. PtRu/C is currently the state-of-the-art catalyst for the anodic methanol oxidation reaction (MOR) for DMFC. However, the inferior performance of PtRu/C catalyst remains one of the major obstacles towards the realization of DMFC. Development of low cost and high performance catalyst is desperately needed for the commercialization of DMFC. Ru leaching is a major problem leading to the deterioration of anode catalyst. The objective of this paper is to investigate the effect of catalyst compositions and preparation methods to the enhancement of catalyst performance in the anodic methanol oxidation reaction (MOR). PtRu based ternary and quaternary catalysts (PtRuX/C and PtRuXY/C, in which X=Ir, W, Cr, Au and Mo; Y=B or P) were prepared in this study in order to determine the best composition to obtain anode catalyst with high activity and durability. Key parameters for the preparation of high performance catalysts such as preparation method, pH of precursor solution, calcinations temperature, support type and metal loading were also investigated. Ternary and quaternary PtRu based catalyst with low MOR onset potential (needed to combat corrosion of Ru), high MOR activity and durability (2–3 times higher than commercial PtRu/C catalyst) were obtained in this study. Details concerning the preparation parameters, catalyst characterization and catalyst fading mode will be revealed in this paper.

Materials and Methods

Ketjen ECP-300 (surface area 855 m2/g) carbon blacks were used as the carbon support for the preparation of PtRu/C catalyst. H2O2 was used as the oxidizing agent for the modification of carbon support. Deposition-precipitation (DP) method, impregnation and incipient wetness methods were used primarily in this study to prepare PtRu based carbon supported catalysts in which the ratio of Pt/Ru is 1/1 (atomic ratio). NaH2PO2, NaBH4 and HCHO were used as the reducing agent in the DP method. After deposition of Pt and Ru onto carbon support, the dried catalysts were activated under hydrogen with or without the presence of water. Glassy carbon electrode surface was polished before the deposition of catalyst. All electrochemical measurements were conducted at 60oC using an Autolab Potentiostat and a conventional three-electrode electrochemical cell. The CV and catalytic MOR activity of catalysts was measured with a RDE. The electrolyte used was 0.5M H2SO4 + 0.5M CH3OH.

Results and Discussion

Table 1 and Figure 1 reveal the MOR activities PtRu/WPC-286, PtRu/WPC-0730 and commercial PtRu/C (Pt:Ru=1:1.5) catalyst. Both PtRu/WPC catalysts are more active than the commercial PtRu/C catalyst. In addition to the higher activity, the onset potentials for the PtRu/WPC catalysts are also lower than the PtRu/C catalyst. This lower onset potential also resulted in the less leaching of the Ru during operation which accounts for the higher durability of the ternary catalysts (Table 1). The higher activities of the ternary catalysts can be explained by the promoting effect of P, which results in the formation of better PtRu dispersion and smaller grain size of PtRu active sites. Details concerning the preparation parameters, catalyst characterization and catalyst fading mode will be revealed in this paper.

Table 1. MOR activity (1 M CH3OH, 40 °C) and durability of PtRu/WPC and commercial catalysts.

<table>
<thead>
<tr>
<th>ID</th>
<th>MOR(A/g) @</th>
<th>Life (sec.)</th>
</tr>
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<tbody>
<tr>
<td>PtRu/WPC-286</td>
<td>3.5</td>
<td>15.2</td>
</tr>
<tr>
<td>PtRu/WPC-0730</td>
<td>4.3</td>
<td>15.5</td>
</tr>
<tr>
<td>Vendor A</td>
<td>No activity</td>
<td>9.0</td>
</tr>
</tbody>
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Figure 1. MOR activity Ternary PtRu catalysts.  Figure 2. TEM of PtRu/WPC286.

References