

## Pt-TiO<sub>2</sub>/C as methanol tolerant cathode catalyst for direct methanol fuel cell

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### Introduction

One of the main impediments to practical realization of the direct methanol fuel cell (DMFC) is cross-over of methanol through the proton conducting polymer membrane, which results in poor cell performance [1-3]. Pt-TiO<sub>2</sub> composite catalyst was found to exhibit high performance in the electrooxidation of methanol [4-6] and carbon monoxide [4]. In this work, Pt-TiO<sub>2</sub>/C was studied of its catalytic activity towards oxygen reduction in the presence of methanol.

### Experimental

The Pt-TiO<sub>2</sub>/C catalyst was prepared through the following procedures: Pt/C was first suspended in ethanol. Titanium isopropoxide was added to the Pt/C suspension under vigorous agitation in an ultrasonic bath. Add drop wise excess of water to the suspension to enable the hydrolysis of titanium isopropoxide. The suspension was stirred for 40 h before the filtering, rinsing and drying processes. RDE technique was adopted in performing the electrochemical measurements. Porous RDE was prepared by “ink” method. Before the modification of catalyst film, the RDE was first cleansed in acetone and then water ultrasonically. A suspension of catalyst was prepared by mixing 8 mg of catalyst powder, 160  $\mu$ l of Nafion solution (5% wt., Aldrich) and 8 ml pure water. 3.5  $\mu$ l of this suspension was transferred onto the vitreous carbon surface of the RDE (0.07 cm<sup>2</sup> in geometric surface area) by a micropipette. It was then vacuum dried at room temperature for 15 minutes to evaporate the solvent contained in the catalyst suspension. Comprised of 1 M H<sub>2</sub>SO<sub>4</sub> and 1 M methanol, the electrolyte was saturated with oxygen before use. Linear potential scan was conducted at room temperature in a conventional three-electrode cell using a platinum foil as counter electrode and a Ag/AgCl as reference electrode. The catalyst modified RDE underwent a fast cyclic voltammetry from -0.4-1.0 V vs. Ag/AgCl for 20 cycles in order to remove the trace of contaminants remained in the catalyst film. Afterwards linear potential scan was carried out from 0.83 V to -0.07 V at a sweep rate of 5 mV/s. This measurement was performed several times until a stable curve was obtained. The rotating rate of the RDE was maintained at 2000 rpm throughout the experiment.

### Results

Fig. 1 shows the polarization curve of Pt-TiO<sub>2</sub>/C catalyst recorded in 1 M H<sub>2</sub>SO<sub>4</sub> and 1 M methanol electrolyte. For comparison the same experiment was performed at an ETEK Pt/C catalyst (40 wt% of Pt). As shown in Fig. 1, the current remains positive at a potential higher than 0.53 V for ETEK Pt/C catalyst and 0.57 V for the Pt-TiO<sub>2</sub>/C catalyst. This positive current was caused by the electrooxidation of methanol. As the potential scanned negatively, the current decreased due to the reduction of oxygen dissolved in the electrolyte. At 0.5 V, the current density was 0.359 and 0.098 A/cm<sup>2</sup> at Pt-TiO<sub>2</sub>/C and ETEK Pt/C catalyst, respectively. At 0.4 V, the current

density was 0.76 and 0.532 A/cm<sup>2</sup> at Pt-TiO<sub>2</sub>/C and ETEK Pt/C catalyst, respectively. Therefore, it is evident that the Pt-TiO<sub>2</sub>/C catalyst possesses a higher catalytic activity towards oxygen reduction than a Pt/C catalyst, in the presence of methanol. It is possible that Pt-TiO<sub>2</sub>/C catalyst can be used as methanol tolerant cathode catalyst for a DMFC.

### References

- 1-C. Pu et al, J. Electrochem. Soc., 142 (1995) L119.
- 2-G.T. Burstein et al, Catal. Today, 38 (1997) 425.
- 3-W.C. Choi et al, J. Power Sources, 96 (2001) 411.
- 4-B.E. Hayden et al, Electrochem. Commun., 3 (2001) 395.
- 5-YANG Hui et al, Chem. J. Chinese Universities, 19 (1998) 1320.
- 6-LIU Chang-peng et al, Chem. J. Chinese Universities, 23 (2002) 1367.

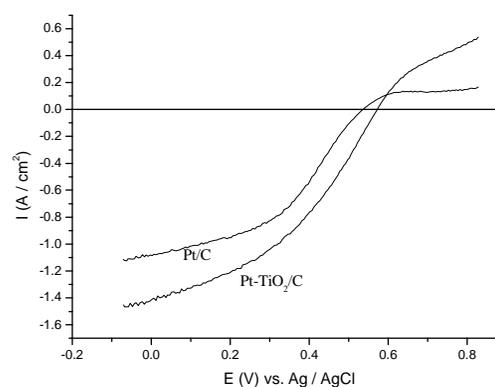


Fig. 1 Polarization curves of Pt-TiO<sub>2</sub>/C and Pt/C in 1 M H<sub>2</sub>SO<sub>4</sub> + 1 M methanol saturated with O<sub>2</sub>. Scan rate: 5 mV/s.