Performance of PEMFC Electrodes Containing Low-Pt Loadings

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Despite the performance improvements achieved by PEMFC's in recent years, their practical implementation, particularly in transportation applications, has been hindered by the high cost of materials such as membranes, bipolar plates and catalysts. Only carbon supported Pt or Pt-alloys are capable of sustaining sufficient high power for long periods of time in the acidic environment existing in proton exchange membranes such as Nafion®. Therefore, the need to decrease Pt loadings (or find a replacement) is a major goal in PEMFC research.

Here we present FC performance results obtained with catalyst loadings considerably under 100 µg Pt/cm^2 at the anode or the cathode. These catalysts have enhanced electroactivity and achieve a more complete Pt utilization. Preparation of these materials has resulted in low-loading electrocatalysts that contain submonolayer-to-monolayer amounts of Pt on nanoparticles of suitable carbon-supported metals or alloys [1,2,3]. Two different catalysts have been tested in fuel cell operation, an anode catalyst consisting of Pt islands on Ru nanoparticles and a cathode catalyst consisting of a Pt monolayer on Pd nanoparticles.

Figure 1 shows a long-term test of a cell with an anode loaded with 18 µg Pt/cm^2 (2 w% Pt-20% Ru/C, BNL). The cell was operated with variable fuel composition (neat H_2 for 630 hr and H_2 + 50 ppm CO + 3% air bleed for 238 hr). The cell did not experience voltage loss (within experimental error) operating on neat hydrogen. This result demonstrates long-term stability of the catalyst despite the very low-Pt content. As expected from a catalyst containing a Pt-Ru alloy, it also presented good tolerance to CO-contaminated H_2. The total loss running with CO was 12 mV compared to operation on neat H_2.

Figure 2 shows performance of FC cathodes containing 40 µg Pt/cm^2 (c) and 77 µg Pt/cm^2 (b) (4w%Pt-20w%Pd/C,BNL). For comparison, a polarization curve obtained with a FC cathode containing 0.23 mg Pt/cm^2 (a) (20 w% Pt/C, ETEK) is also included. The performance of cell (b) relative to cell (a) represents a significant improvement in power output to platinum used, as indicated by the numbers of the second column in Table I.

Acknowledgment
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References
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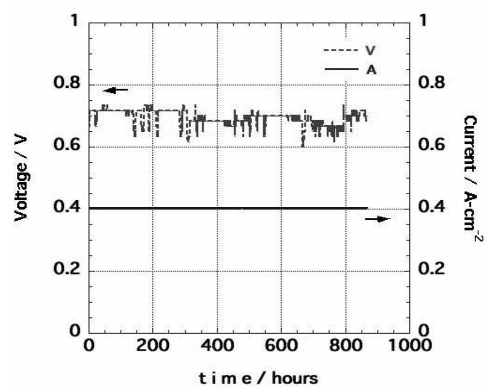

Figure 1. Long-term performance of a FC anode containing 18 µg Pt/cm^2 Loadings: A: 0.20 mg Pt-Ru/cm^2(2 w% Pt-20% Ru/C): C: 0.24 mg Pt/cm^2(20 w% Pt/C, ETEK). 50 cm^2 cell run at 0.4 A/cm^2 constant current. Nafion® 1135 1.3 H_2 stoich/2100 sccm. Back pressures:30 psig. T: 80 °C.

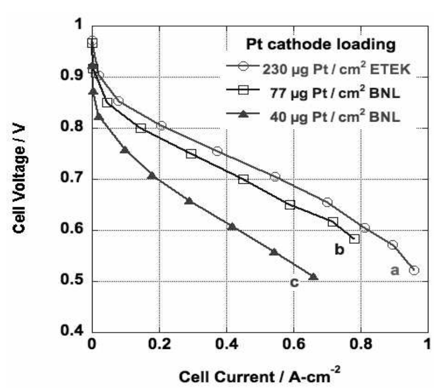

Figure 2. Performance of FC cathodes containing 230 (a) 77 (b) and 40 (c) µg Pt/cm^2. Anode loadings: 0.2 mg Pt/cm^2. 50 cm^2 cell. Nafion® 1135. 1.3 H_2 stoich/2100 sccm. Back pressures:30 psig. T: 80 °C.

Table I: Performance loadings at 0.6 V (g/kW) (from curves in Fig. 2).

Cell	g Metal/kW	g Pt/kW
a	0.92	0.92
b	1.0	0.59
c	1.1	0.80

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