Development of Ultra-Low Loading Pt Hybrid Catalyst for PEM Fuel Cells

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Our strategy to decrease the platinum loading in the cathode is based on synergetic effects of CCC (carbon composite catalyst, free of platinum) on which Pt or Pt alloy catalysts is deposited, thus forming two types of hybrid catalysts Pt/CCC and Pt-alloy/CCC (HCC) catalysts [1-5].

The goals are: (i) to achieve kinetic mass activity in H_2/O_2 fuel cell higher than the DOE 2017 target of 0.44 A mg_{PGM}^{-1}, (ii) to demonstrate durability of the kinetic activity per DOE cycling protocol between 0.6 and 1.0 V, and with performance loss less than 40% (iii) to accomplish high current density performance and durability in H_2/air fuel cell to meet 2017 DOE targets.

Cell diagnostics of the cathode catalysts such as ECSA, ORR mass activity, and oxygen polarization curves were performed after 5,000, 10,000, 20,000, and 30,000 cycles. The support durability was studied by applying 1.2 V vs. SHE constant potential with respect to the anode for 400 hours according to the DOE protocol. The hybrid Pt catalyst synthesized at USC shows synergetic effect between the catalytically active no platinum-CCC support and Pt catalyst. CCC was synthesized with onset potential for oxygen reduction of 0.92 V vs. SHE and with less than 2.5% H_2O_2 production.

In Figure 1, Pt/CCC_{140} shows onset potential of 1.05 V vs. SHE, much improved kinetics compared with commercial catalyst Pt/C and the smallest mass transfer limitation (with highest diffusion limitation current).

As shown in Figure 2, Pt/CCC_{140} exhibits mass activity of 0.29A/mg_{Pt} compared with 0.18 mass activity measured for commercial 46%Pt/C (TKK) catalyst. Mass activity loss after 200 h potential holding was only 24% compared with 58% loss observed for commercial catalyst after 24 hours.

The potential holding experiment at 1.2 V for the support durability of Pt/CCC_{140} showed only 6 mV loss after 200 hours indicating very stable support and catalyst (Figure 3). The observed voltage loss for commercial catalyst was higher than 250 mV after 200 h potential holding test at 1.2 V vs. SHE.

Detailed experimental results and theoretical studies explaining the synergetic effect of Pt hybrid catalyst on the mass activity and high current density performance under H_2-air will be presented at the conference.

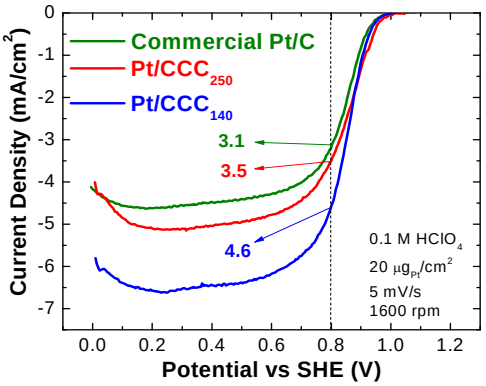

Figure 1. ORR of Pt/CCC_{250}, Pt/CCC_{140} and Pt/C catalysts in the rotating disk electrode.

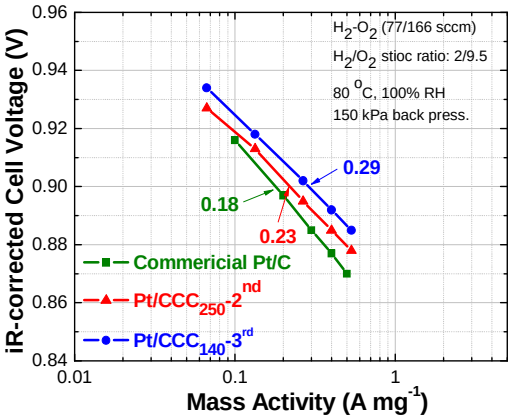

Figure 2. Comparison of kinetic mass activities of Pt/CCC_{250}, Pt/CCC_{140} and Pt/C catalysts in fuel cell.

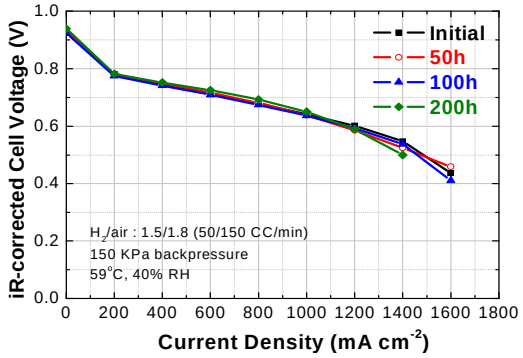

Figure 3. Support Durability Studies of the Pt/CCC_{140} in H_2-Air fuel cell conditions.

References

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