

# Effect of Fabrication Technique on Direct Methanol Fuel Cells Designed to Operate at Low Airflow

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## Introduction

Direct Methanol Fuel Cell (DMFC) technology has matured to a level that has allowed complete fuel cell systems to be fabricated [1]. The airflow at which a DMFC operates determines the fuel cell system water balance, efficiency, and total mass [2,3]. Methanol crossover increases the airflow rate requirements of the DMFC system [4]. Thus, one of the solutions to minimizing the airflow rate requirements of a DMFC system is to curb methanol crossover. The addition of constituents such as hydrophobic particles to the cathode of DMFCs has been demonstrated to mitigate the effects of crossover and decrease the airflow required [4]. This paper will present the effects of catalyst ink constituents and membrane electrode assembly (MEA) fabrication techniques on suppressing the effects of crossover. Particular attention was focused on increasing the overall cell efficiency.

## Experimental

Several MEAs have been fabricated by variants of the Jet Propulsion Laboratory Direct Deposit Technique [5]. Each of these MEAs consists of a Pt-Ru-Black (50:50) anode, a Pt-Black cathode, and Nafion as the polymer electrolyte. The catalyst used to fabricate these MEAs was purchased from Johnson Matthey. Variations in fabrication technique included membrane treatment and catalyst application process. The catalyst constituents studied included hydrophobic particles and proton-conducting substances added to the catalyst mix. Current-voltage behavior of the cell, anode polarization, and crossover experiments were used to determine the impact of varying catalyst constituents and MEA fabrication techniques on cell performance.

## Results and Discussion

The effect of airflow on cathode performance for a DMFC with hydrophobic particles in the cathode layer operating at 60 °C, 0.5M MeOH is shown as figure 1. Increasing the airflow rate beyond 0.15 LPM has a minimal effect on the cathode performance at 100 mA/cm<sup>2</sup>. The addition of hydrophobic particles is anticipated to increase the availability of oxygen to the catalytic sites by improved water rejection.

The effect of DMFC fabrication technique on cell efficiency can be seen in figure 2. A DMFC peak efficiency of 28.9% and power density of 55.7 mW/cm<sup>2</sup> can be obtained at 60 °C, 0.1 LPM airflow. This is an 8% increase in peak efficiency and a 13% increase in peak power density over previous low airflow cell designs.

The results shown in figure 3 demonstrate that the incorporation of proton conducting substances such as hydrous RuO<sub>2</sub> in the anode is beneficial in reducing the catalyst loading. Preliminary results show that RuO<sub>2</sub> is effective at lowering the total cell resistance and in increasing the overall cell efficiency.

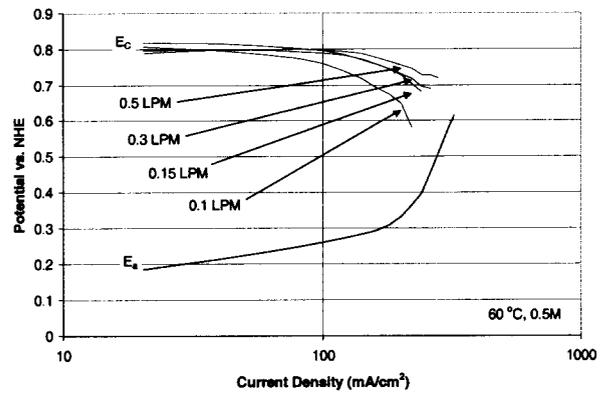


Figure 1. Cathode performance as a function of airflow rate and applied current density for a DMFC. (60 °C, 0.5M MeOH, ambient pressure air)

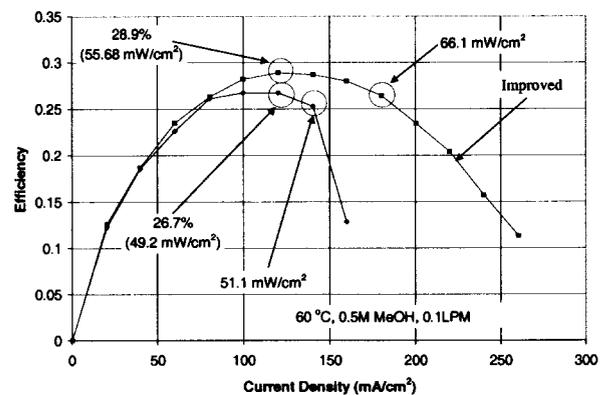


Figure 2. Cell efficiency and peak power densities as a function of applied current density for typical and state-of-art DMFC. (60 °C, 0.5M MeOH, 0.1 LPM ambient pressure air)

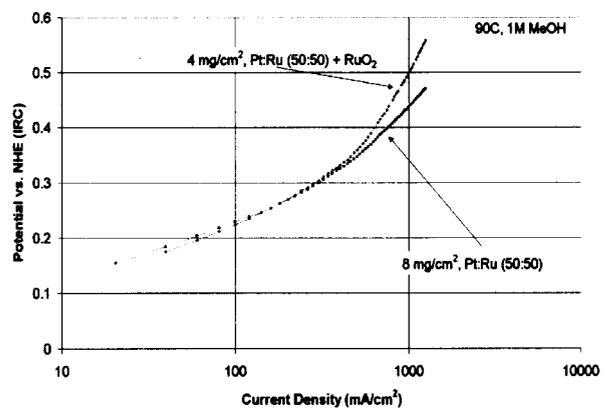


Figure 3. Internal resistance corrected anode potential as a function of applied current density for a DMFC with and without Hydrous RuO<sub>2</sub>. (90 °C, 1M MeOH)

## References

- 1-Kindler, A., Methanol Fuel Cells, ECS Proceeding Series, Pennington, NJ. 2001 pg. 231 –240
- 2-Narayanan, S.R., Proceedings of Proton Conducting Membrane Fuel Cells II, ECS Proceeding Series, Pennington, NJ. 1998 pg. 316 –326
- 3-Valdez, T.I., Proceedings of the 11th annual Battery Conference on Applications and Advances, Long Beach, CA., Jan 9-12, 1997. IEEE pg. 239 - 244
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- 5- Narayanan *et al*, Patent No: 6221,523, Direct Deposit of Catalyst on the Membrane of Direct Feed Fuel Cells.