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**Title:** METHANAL CROSSOVER IN DIRECT METHANOL FUEL  
CELL SYSTEMS

**Author(s):** Bryan S. Pivovar,  
Guido Bender,  
John Davey,  
Piotr Zelenay,

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## Methanol Crossover in Direct Methanol Fuel Cell Systems

Bryan S. Pivovar, Guido Bender, John Davey,  
Piotr Zelenay

Electrochemical and Electronic Materials and  
Devices, MST-11  
Los Alamos National Laboratory,  
Los Alamos, NM 87545

Direct methanol fuel cells (DMFCs) are currently being investigated for a number of different applications from several milliwatts to near kilowatt size scales (cell phones, laptops, auxiliary power units, etc.). Because methanol has a very high energy density, over 6000 W hr/kg, a DMFC can possibly have greatly extended lifetimes compared to the batteries, doesn't present the storage problems associated with hydrogen fuel cells and can possibly operate more efficiently and cleanly than internal combustion engines.

A common pitfall for DMFCs has been the inability of the electrolyte to act as an effective methanol barrier. This reduces cell performance due to a mixed potential at the cathode and lowers fuel efficiency due to the loss of methanol reacting at the anode. DMFC systems have been shown to operate at fuel efficiencies near 90% (1). In order to maintain high fuel efficiency, and therefore high system efficiency, the methanol crossover rates need to be minimized for the current operating conditions. For dynamic operation of a DMFC system this requires knowledge of the response of methanol crossover to system conditions, i.e. temperature, methanol concentration, and current density.

Figure 1 shows methanol crossover as a function of temperature for a typical DMFC membrane electrode assembly (MEA) that we use in our DMFC systems. Figure 2 shows methanol crossover as a function of methanol concentration in the same MEA. The trends of increasing crossover with concentration and temperature are not surprising. Decreasing crossover with increasing current density is also a common feature for these graphs. A detail of these graphs that is often overlooked is the limiting crossover current that is reached at higher current densities.

The limiting crossover current region is of special interest because DMFCs operate most efficiently when crossover is minimized, and

some strategies for systems involve throttling the methanol concentration to maintain optimum efficiency according to system demand.

The high current region is explored using a segmented cell to explain the asymptote reached at high current density, and a transport-based model will be presented that shows good agreement with the experimental data up to high current densities. The results of these experiments and their applicability to DMFC systems will be discussed.

### References

1. Ren, X., Zelenay, P., Thomas, S., Davey, J., and Gottesfeld, S., *J. Power Sources*, 86, 111-116, 2000.

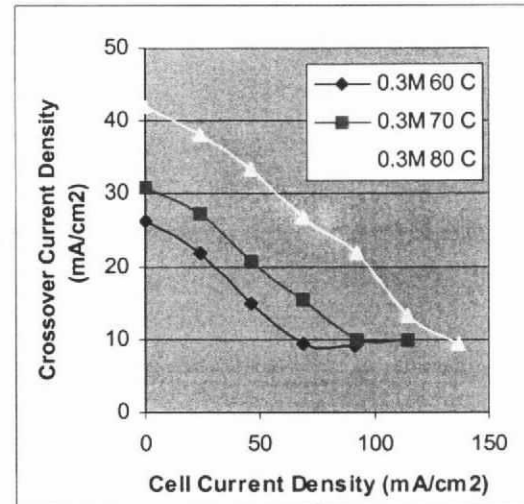


Figure 1: Crossover current density versus cell current density as a function of temperature.

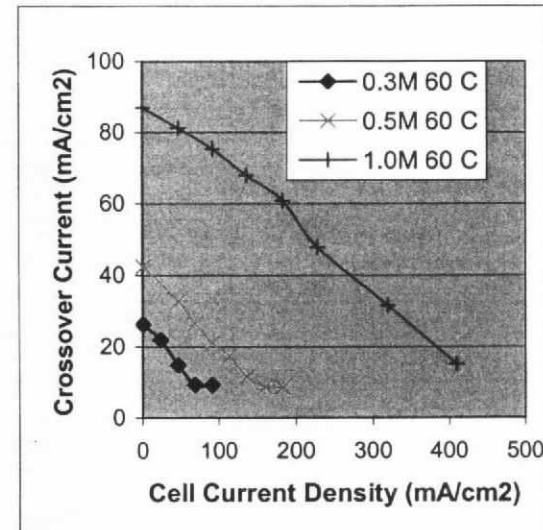


Figure 2: Crossover current density versus cell current density as a function of methanol concentration.