Faradaic Efficiencies for Methanol Oxidation in Proton-Exchange Membrane Electrolysis and Fuel Cells with Various Anode Catalysts

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The energy efficiency of a direct methanol fuel cell (DMFC) is dependent on the cell voltage, crossover of oxygen and/or methanol through the polymer electrolyte membrane, and stoichiometry of the methanol oxidation reaction (i.e., the average number of electrons transferred per methanol molecule (n_{av})). The stoichiometry is determined by the product distribution (carbon dioxide: formic acid: formaldehyde) and the amount of methanol consumed. The influence of crossover is investigated by using air and N₂ at the cathode. Accurate determination of n_{av} requires analysis of the methanol and products from both the anode and cathode and quantitative determination of the consumption of methanol. In this work, n_{av} values obtained from the analysis of the cell exhausts by proton NMR and infrared spectrometry are compared with values obtained from a simple electrochemical method based on the dependence of the current on the flow rate of the methanol solution. The methodology presented here provides a comprehensive evaluation of methanol oxidation, along with a full determination of the methanol consumption and hence the fuel efficiency of the cell. The methods are suitable for rapid evaluation of catalysts in fuel cell hardware with low-cost online sensors for determination of product distributions.

Keywords: direct methanol fuel cell; methanol electrolysis cell; crossover; product distribution; flow rate; stoichiometry; efficiency

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