45% Cell Efficiency in DMFCs by Process Engineering

Andreas Glüsen, Martin Müller, Detlef Stolten
Forschungszentrum Jülich
Institute for Energy and Climate Research - IEK-3: Energy Process Engineering
Wilhelm-Johnen-Straße, D-52425 Jülich
Tel.: +49-2461-61-5171
Fax: +49-2461-61-6695
a.gluesen@fz-juelich.de

Abstract

Methanol is a convenient liquid fuel for fuel cells, but it is not converted as efficiently into electrical energy as hydrogen. This is due to slower reaction of methanol at the anode, leading to higher over potential, and to methanol permeation leading to a loss of fuel and a mixed potential at the cathode. At the same time, permeation is helpful to keep the cell at a useful operating temperature of 70°C in spite of the cooling effect of water evaporating at the cathode.

When optimizing the DMFC process, methanol concentration and flow rate, current density and air flow rate must be regarded. A high methanol concentration facilitates operation at high current densities but leads to high methanol permeation as well. The air flow rate must be adjusted so that the cooling effect of evaporating water is balanced by the heat produced in the cell. Therefore, a cell with low permeation has to be operated at low air flow rates to achieve autothermal operation, which can in turn reduce cell performance. For each current density, there is an optimum amount of methanol feed (Figure 1 a).

In this paper we show, how these effects have to be balanced using air-flow rates calculated to ensure thermal equilibrium. As a result, it is possible to achieve electrical cell efficiencies up to 44% of the lower heating value of methanol in a self-heating DMFC (Figure 1b).

Another increase in efficiency can be achieved by using humidified air at the cathode. This allows using a higher cathode volume flow while still maintaining a high cell temperature.

![Graph](image)

Figure 1: a) Change in performance at constant current density with change in methanol feed and b) Efficiency and power density of all auto thermal operating states (line through maxima is a guide for the eye)