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Water management in a passive direct methanol fuel cell

Vânia B. Oliveira[1], Daniela S. Falcão[1], Carmen M. Rangel[2] and Alexandra M. F. R. Pinto[1,*,†]

[1]Centro de Estudos de Fenómenos de Transporte, Departamento de Eng. Química, Faculdade de Engenharia da Universidade do Porto, Porto, Portugal
[2]Fuel Cells and Hydrogen, Laboratório Nacional de Energia e Geologia, Lisboa, Portugal

SUMMARY

Passive direct methanol fuel cells (DMFCs) are under development for use in portable applications because of their enhanced energy density in comparison with other fuel cell types. The most significant obstacles for DMFC development are methanol and water crossover because methanol diffuses through the membrane generating heat but no power. The presence of a large amount of water floods the cathode and reduces cell performance. The present study was carried out to understand the performance of passive DMFCs, focused on the water crossover through the membrane from the anode to the cathode side. The water crossover behaviour in passive DMFCs was studied analytically with the results of a developed model for passive DMFCs. The model was validated with an in-house designed passive DMFC. The effect of methanol concentration, membrane thickness, gas diffusion layer material and thickness and catalyst loading on fuel cell performance and water crossover is presented. Water crossover was lowered with reduction on methanol concentration, reduction of membrane thickness and increase on anode diffusion layer thickness and anode and cathode catalyst layer thickness. It was found that these conditions also reduced methanol crossover rate. A membrane electrode assembly was proposed to achieve low methanol and water crossover and high power density, operating at high methanol concentrations. The results presented provide very useful and actual information for future passive DMFC systems using high concentration or pure methanol. Copyright © 2012 John Wiley & Sons, Ltd.

KEY WORDS

passive direct methanol fuel cell; modelling; water crossover; net water transport coefficient; fuel cell performance

Correspondence

*A. M. F. R. Pinto, Centro de Estudos de Fenómenos de Transporte, Departamento de Eng. Química, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, 4200–465 Porto, Portugal.
†E-mail: apinto@fe.up.pt

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1. INTRODUCTION

Direct methanol fuel cells (DMFCs) offer many advantages when compared with polymer electrolyte membrane fuel cells, such as no need for humidification, low cost and simple design and methanol is easy to storage and transport. In the last years, the passive direct methanol fuel cell based on passive fuel and oxidant feeding has attracted a considerable amount of attention as a more suitable power source for portable devices such as mobile phones, PDAs, laptops and multimedia equipment [1–35]. However, the commercialization of DMFCs is still hindered by several technological problems, among which, the methanol crossover and the water management are key issues [1–35]. Like the active ones, the passive systems suffer from methanol crossover when the cell is operated with high methanol concentration solutions, although more concentrated methanol solutions would be preferable to achieve energy densities needed for portable power applications. It should be noted that in passive DMFC systems, the methanol is only delivered to the catalyst layer in a passive diffusion mode. Under this condition, if methanol is not supplied adequately and timely, polarization of the cell voltage may occur because of the lack of methanol. Also, the output of a passive DMFC with lower methanol concentrations is not acceptable for real applications. To solve this problem, some work has been performed to operate a passive DMFC with highly concentrated methanol solution or even neat methanol [1–11,14–16,19,21–23,26–28,30,32,33]. So low crossover of methanol in passive DMFC systems is essential for using high-concentration methanol solutions in portable power applications. Different approaches including improving the electrolyte membranes, fuel feed system and altering the cell structure have been proposed in the last years [3–10,15,19,21–23,26,27,30,32,33].

Water crossover through the membrane may cause two problems for the passive DMFC systems. First, it results in a water loss from the anode, and thus, make-up of water is