Internal Reforming Methanol Fuel Cell

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Introduction

Though H_2 is being considered as the optimum fuel for Polymer Electrolyte Membrane Fuel Cells (PEMFCs), its low volume energy density renders its use difficult in mobile or portable applications. As an alternative, the direct and efficient processing of methanol has been extensively considered as a potential near-term solution for the successful implementation of portable fuel cells. Methanol can be considered as a potential alternative due to its high volume energy density [1,2]. It is easily handled and almost sulphur-free, while it is catalytically reformed at low temperature (200-300°C) with low selectivity to undesired CO. Here, we demonstrate for the first time a compact single power unit, where a methanol reforming catalyst is incorporated into the anode of a PEMFC [3].

Materials and Methods

Synthesis, casting and doping of copolymer dPPy(10)coPPy(54)coT(36)S electrolyte membrane. Bis-(4-fluorophenyl)sulfone, 3.3',5.5'-Tetramethyl-[1.1'-biphenyl]-4.4'-diol, 2.5-Bis(4-hydroxy-phenyl)pyridine, 2.5-di(Pyridin-3-yl)benzene-1.4-diol, K_2CO_3, DMF and toluene were added to a flask, degassed under Ar, stirred at 150°C (24 h) and at 180°C (48 h). The obtained viscous product was diluted in DMF and precipitated in a 10-fold excess mixture of CH_3OH, washed with H_2O and hexane, and dried at 80°C under vacuum. dPPy(10)coPPy(54)coT(36)S copolymer was dissolved in dimethylacetamide (DMA) at RT. The solvent was slowly evaporated at 70°C (24 h) dried in vacuum at 160°C (72 h) resulting into a polymer film of 50-70 μm thickness. The membrane was immersed in 85 wt% phosphoric acid at 100°C (8 h) in order to reach a doping level 260 wt%.

Electrocatalytic layer. The catalytic layer was sprayed onto the GDL by the use of a DMA suspension (1:1 by weight HP E-TEK Pt/C catalyst and dPPy(10)coPPy(54)coT(36)S binder). The electrode loading was 1 mg Pt/cm^2. The electrode was sintered in a vacuum oven at 190°C for the solvent removal. The Pt/C electrodes were hot pressed (150°C, 10 bar, 25 min), to the dPPy(10)coPPy(54)coT(36)S acid doped polymer electrolyte membrane in a die set up using Teflon (Dupont, USA) and polyimide gaskets.

Reforming catalyst. 6.5 g of Cu-Mn-O (atomic ratio Cu/(Cu+Mn) = 0.30) spinel oxide supported on Cu foam (M-Pore, 20 ppi, 10 cm^2 x 1 cm thickness) were prepared via the combustion method and used as methanol reforming catalyst, without additional treatments [4].

Results and Discussion

Here, we demonstrate for the first time a compact single power unit, where a methanol reforming catalyst is incorporated into the anode of a PEMFC (Fig. 1). The proposed Internal Reforming Methanol Fuel Cell (IRMFC) mainly comprises: (i) a novel H_3PO_4-imbibed polymer electrolyte based on aromatic polyethers baring pyridine units, able to operate at 200°C and (ii) a 200°C active and with zero CO emissions Cu-Mn-O methanol reforming catalyst supported on copper foam. Methanol is being reformed inside the anode compartment of the fuel cell at 200°C producing H_2, which is readily oxidized at the anode to produce electricity. The "waste" heat of the cell is utilized in-situ to drive the endothermic methanol reforming reaction. The IRMFC operated efficiently for more than 72 h at 200°C with a current density of 263 mA cm^{-2} at 500 mV, when 20% CH_3OH/30% H_2O/He (anode feed) and pure O_2 (cathode feed) were supplied (Fig. 2). Its open circuit voltage was 990 mV. It was interestingly observed that due to H_2 utilization/depletion at the anode the reforming reaction rate was enhanced even up to 20%. It is estimated that a sixfold increase in the system's volume power density can be achieved as compared to the conventional combination of a methanol reformer and a PEM fuel cell.

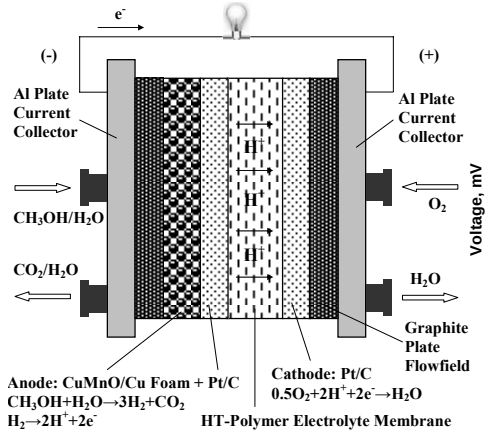

Figure 1. IRMFC configuration.

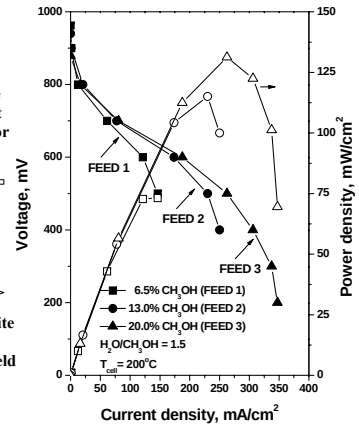

Figure 2. IRMFC polarization curves.

Significance

The present research approach enables the development of low-cost, efficient reformed hydrogen fuel cells for mobile or portable applications.

References

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4. Papavasiliou, J., Avgouropoulos, G., and Ioannides, T. *Appl. Catal. B: Environ.* 66, 168 (2006).