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Development of improved passive configurations of DMFC with reduced contact resistance

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Abstract

The Direct Methanol Fuel Cell (DMFC) represents today an appropriate solution for powering portable applications and small electronic devices, due to: 1) its compactness, 2) the high power density when compared with batteries and 3) the facility in transporting proper quantities of fuel (generally a liquid mixture of methanol and water).
In order to further reduce the DMFCs size, passive configurations without external pumps and auxiliary devices are actively studied. Oxygen is supplied from the surrounding air while methanol-water solution is stored into a built-in tank in contact with the gas diffusion layer (GDL) that is constantly kept wet.
Such configurations have a lower current density, roughly around 10÷30 mA/cm2, when compared with active configuration (40÷80 mA/cm2). It is then important to improve the baseline performance (power and efficiency) of such cells by optimizing all system components.
Here we aim at reducing the effects of the contact resistance between GDL and current collectors by carrying out a sensitivity analysis on a number of relevant cells parameters such as:. assembly shape, gaskets, current collectors materials and open ratios. Analysis will be carried out at different molar concentrations (1 to 4 M) of the water-methanol solution used as fuel.

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Keywords: DMFC, methanol, passive, fuel cell

1. Introduction

Fuel cells are an attractive solution for stand alone and portable applications [1,2] due to the high efficiency of the energy conversion, low emissions, modularity and scalability. In particular the use of liquid fuels, such methanol, improves the handling, reduces the volume and the critical aspects of the system [3,4]. The aim of this work is to investigate the direct methanol fuel cell (DMFC) performance in passive configuration (PDMFC) with different sealing gaskets and molar concentrations.

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2. Material and Methods

2.1. MEA and single cell fixture

For the experiments we used a commercial Membrane Electrode Assembly (MEA) made by Fuel Cell Etc.

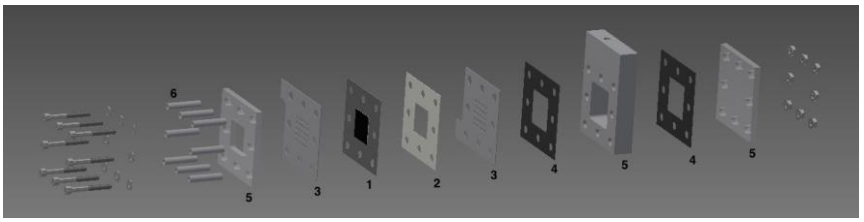


Fig. 1. Cell assembly

Assembly consists of:

1) MEA: Nafion 117, anode catalyst layer with a catalyst load of 4 mg/cm^2 PtRu and cathode catalyst layer of 4 mg/cm^2 of PtBlack, GDLs made of woven carbon cloth.
2) PTFE or silicon gasket
3) Current collectors
4) Silicon gaskets
5) Plexiglass support structure
6) PTFE screw joint insulators

The test assembly was packed with eight M4 screw joints tightened with a torque of 2,2 Nm.

2.2. Methodology and parameters

The cell performance was investigated with the change of two parameters to reduce the contact resistance: 1) gaskets thickness and material and 2) methanol concentration with 1, 2 and 4 M. Due to the low power of the DMFC working in passive configuration and at room temperature the contact resistance is a significant parameter. Gaskets in addition to prevent fluid leakage must favour the contact between GDLs and current collectors. In the previous study [5] we noticed that a sealing in the cathode side is not needed but the thickness and materials of the gaskets in the anode influence the good DMFC working. In this study three different gaskets, listed in Table 1, were tested with the use of the plate A and 2 M solution.

Table 1. Gasket materials and thickness

	Thickness (*mm*)
PTFE1	0,4
Silicon	0,5
PTFE2	0,2

In order to control reactants flux, in the active area of the MEA, and further reduce methanol cross-over several authors tested the fuel cell behaviour changing the OR as significant parameter [6,7,8]. In the

present study the reactants distribution on the catalyst layer is identified as the main feature of cell configuration. Keeping a constant OR the plate geometry and the molar concentration [9] were changed.

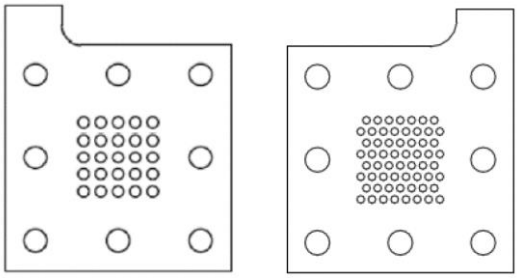


Fig. 2. Plates geometry

Table 2. Plates geometry

	Diameter (*mm*)	N (holes)	OR
Plate A	3	25	36
Plate B	2	60	38

2.3. Measurement procedure

Data acquisition for VI and power curves was made with a Bio-Logic® SP-150 potentiostat . Once the MEA was activated the following measurement procedure was applied.

- Open Circuit Voltage (OCV) was detected for 1 minute and 30 seconds
- 20 minutes at the costant voltage of 0,35 V monitoring the current
- 1 minutes at OCV registering the new voltage value
- V-I curves were carried out using voltage steps of 1 mV/s, starting from 0,5 V until 0,15 V
- Another V-I curve was carried out using voltage steps of 1 mV/s, starting from 0,15 V until 0,5 V
- 1 minutes at OCV registering the new voltage value
- 40 minutes at the costant voltage of 0,35 V monitoring the current
- Anode washing before the new test

3. Results and discussion

The GDL thickness is 410 µm nevertheless the PTFE with thickness 0,4 mm seems does not give a sufficient adherence between GDL and current collector. The silicon gasket gives a better adherence due to its characteristic elastic behavior under load whereas the better performance is given by the PTFE with 0,2 mm that reduces the Ohmic resistance as can be seen by the linear portion of the curve.

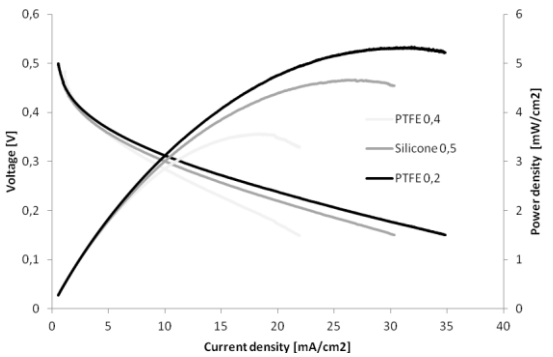
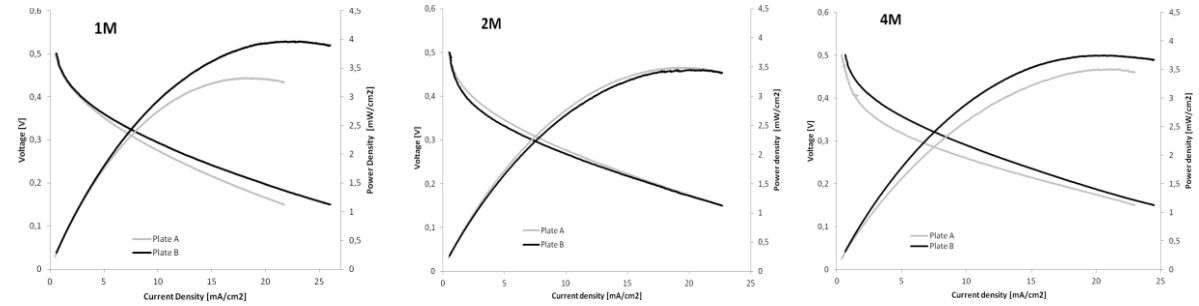


Fig. 3. Cell performance with different gaskets, plate A, 2M

At low concentration, relative slope between the VI curves is divergent whereas at high concentration the relative slope converges. At 1M and high current density, where the drag component of cross-over is the same for the two plates, concentration loss influence badly the voltage drop of the plate A. Plate B favours an homogeneous distribution over all the active area. At high concentration and low current density the diffusive component of cross-over become more significant for plate A, where the holes diameter is larger, then increasing the current density the two plates are going to converge because methanol consumption increases and diffusive cross-over, for plate A, decreases. At 2M the behaviour of two plates is almost the same.



a) b) c)

Fig. 4. VI and power curves a) 1M b) 2M and c) 4M

Homogeneous distribution of holes upon current collector surface favours a better distribution of reactants in the catalyst layer and decreases the cross-over effects. Further analysis with impedance method are currently being made in order to confirm VI curve analysis.

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