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Development of Multi-layer Electrode for Direct Methanol Fuel Cell

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1. Introduction

The major problems of DMFC are i) methanol crossover through the membrane to the cathode side, decreases the oxygen kinetics, and the cell potential in turn affecting the efficiency of the system. ii) the formation of CO_2 at the anode side blocks the active site of the catalyst. A DMFC operating at normal atmospheric pressure and temperature between 60 to 90℃ using dry air tremendously increases the scope for traction and other potential applications. The present work is mainly concentrated on low loading noble metals and operating at low temperature and pressure. The highest temperature used is 110℃. Comparative studies have been carried out using various commercially available anode catalysts for DMFC.

2. Experimental

The performance of the direct methanol fuel cells using various anode and cathode catalysts system have been studied. The DMFC performance assembled by double-layered anode and cathode electrode were examined. The schematic picture of the multi-layer electrode used in this experiment was shown in figure 1. The effect of membranes such as Nafion 115 and 117 was also examined. The electrode assemblies used in this study had an active area of 25 cm^2. The cell was assembled using gold-coated copper end plate. 2 M methanol was feeded into the cell using programmable mass flow controller with a flow rate of 2 ml/min in all the experiments. The catalyst slury was prepared using a mixture of isopropyl alcohol and water and

followed by the addition of Nafion or teflon binder. Table 1 shows sample preparation conditions in this experiment.

Table 1. sample preparation condition in this experiment.

MEA No.	cathode electrode			anode electrode		
	diffusion layer	1st layer	2nd layer	diffusion layer	1st layer	2nd layer
1	C · B + teflon binder	2 mg/cm^2 Pt black + teflon(25%)	2 mg/cm^2 Pt black + Nafion(15%)	C · B + Nafion binder	1 mg/cm^2 Pt-Ru/C + Nafion (33 %)	1 mg/cm^2 Pt-Ru black + Nafion(25 %)
2	"	"	"	"	"	0.3 mg/cm^2 Pt-Ru/C + Nafion(33 %)
3	"	"	"	"	"	1 mg/cm^2 Pt-Ru black + Nafion(25 %)
4	"	"	1 mg/cm^2 pt black + Nafion binder(15 %)	"	0.5 mg/cm^2 Pt-Ru/C + Teflon(20 %)	0.5 mg/cm^2 Pt-Ru black + Nafion (25 %)

No. 1, 2, 4: Nafion 117 and pressured at 4 Kgf/cm^2 for 3min.

No. 3: Nafion 115 and pressured at 3 Kgf/cm^2 for 3min.

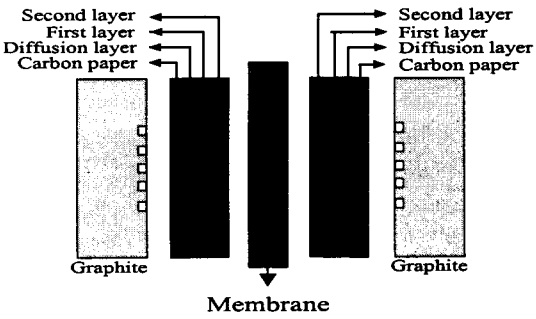

Fig. 1. Schematic picture of multi-layer electrode Used in this experiments

3. Results

Fig. 2 show the single cell performance of MEA 1 under the ambient (Fig. 2a) and 2 bar oxygen pressure (Fig. 2b). The Maximum power density was shown to 120 and 130 mW/cm^2 at 0.4V, 60℃ under the ambient and 2 bar oxygen pressure, respectively.

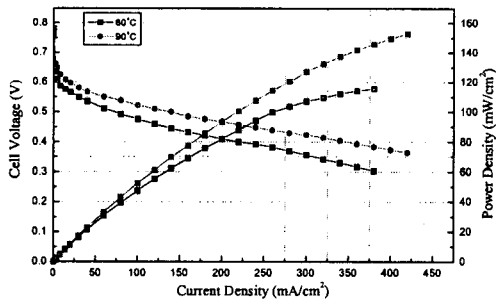

Fig. 2a. Single cell performance of MEA 1 at the ambient pressure of oxygen.

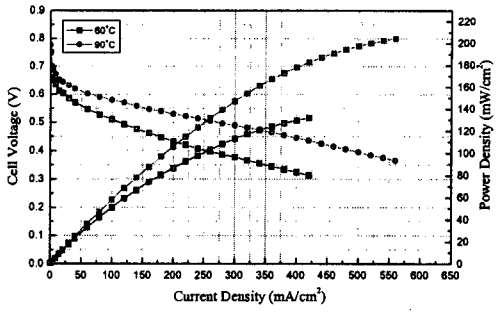

Fig. 2b. Single cell performance of MEA 1 at the oxygen pressure of 2 bar.

Fig. 3 show the single cell performance of MEA 2 under the ambient (Fig. 3a) and 2 bar oxygen pressure (Fig. 3b). The Maximum power density was shown to 40 and 50 mW/cm^2 at 0.4V, 60℃ under the ambient and 2 bar oxygen pressure, respectively.

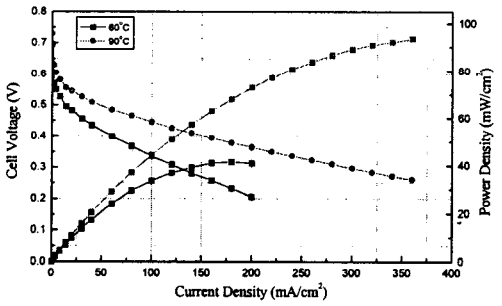

Fig. 3a. Single cell performance of MEA 2 at the ambient pressure of oxygen.

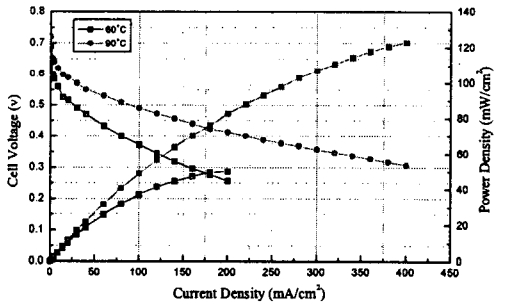

Fig. 3b. Single cell performance of MEA 2 at the oxygen pressure of 2 bar.

Fig. 4 show the single cell performance of MEA 3 under the ambient (Fig. 4a) and 2 bar oxygen pressure (Fig. 4b). The Maximum power density was shown to 65 and 140 mW/cm^2 at 0.4V, 60℃ under the ambient and 2 bar oxygen pressure, respectively.

Fig. 5 show the single cell performance of MEA 1 under the ambient (Fig. 5a) and 2 bar oxygen pressure (Fig. 5b). The Maximum power density was shown to 22 and 30 mW/cm^2 at 0.4V, 60℃ under the ambient and 2 bar oxygen pressure, respectively.

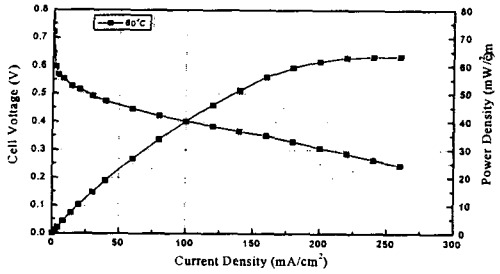

Fig. 4a. Single cell performance of MEA 3 at the ambient pressure of oxygen.

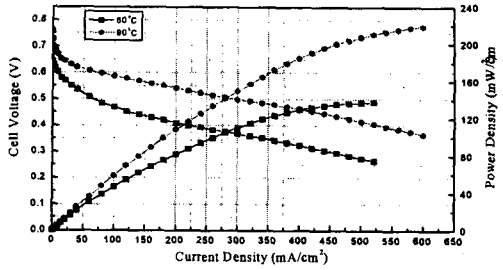

Fig. 4b. Single cell performance of MEA 3 at the oxygen pressure of 2 bar.

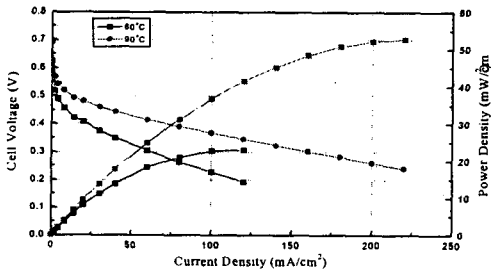

Fig. 5a. Single cell performance of MEA 4 at the ambient pressure of oxygen.

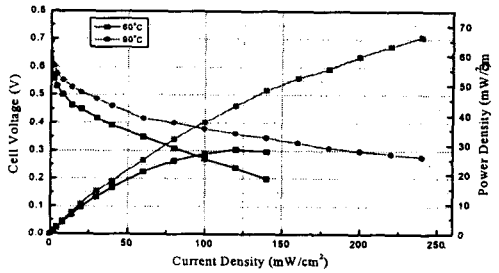

Fig. 5b. Single cell performance of MEA 4 at the oxygen pressure of 2 bar.

4. Conclusions

The present study was performed to reduce the amount of the metal catalyst actually loaded in the MEA system without decreasing the overall performance of the DMFC. The amount of the catalyst used in this experiment reduced to 4-3 mg/cm^2 in cathode and 2-1 mg/cm^2 anode, however, the overall performance was maintained almost the same compared to the general commercial product. The MEA prepared by a multi-layer electrode could reduce the amount of the metal catalyst about 1/2-1/4 compared to the general commercial product, without the loss of the performance. It is better to reduce the amount of catalyst in anode than cathode catalyst without the performance decrease. The best performance was shown in this experiment of the MEA 3 at 90℃ used Nafion 115. It should be that the diffusion of methanol was occurred easily in the multi-layered electrode, and the effect of the teflon and Nafion binder, because the oxidation reaction of methanol appeared between the surface of Nafion membrane and the second layer.