Performance Degradation Study of Direct Methanol Fuel Cell with Operation Time
조업시간에 따른 직접 메탄올 연료전지의 성능 저하 연구

Min Ku Jeon, Kwang Seok Oh, Seong Ihl Woo*
Department of Chem. and Biomolecular Eng. & Center for Ultramicrochemical Process Systems (CUPS), Korea Advanced Institute of Science and Technology

1. Introduction

Direct methanol fuel cell (DMFC) is widely studying for applications in portable power sources such as cellular phone and personal digital assistant because of high energy density and easy storage of the liquid fuel. There are some obstacles preventing DMFC from commercialization. The issues on catalyst is high Pt loading, low activity and stability of catalysts [1]. The life-time of catalyst is a key factor which determines the life-time and cost of DMFC. In spite of the importance of the life-time, there have been no reports on long-time stability of DMFC.

In the present study, life time dependence of DMFCs prepared with Pt and PtRu black catalysts as cathode and anode, respectively, was conducted. Degradation of performance and change of catalysts were studied.

2. Experimental

Pt and PtRu black catalyst ink were prepared with deionized water, isopropylalcohol and Nafion ionomer solution as cathode and anode catalysts, respectively. The catalyst ink were sprayed on PTFE films to adjust catalyst loading to be 2 mg/cm^2. The sprayed PTFE films were dried for 24 hours at room temperature and hot pressed with Nafion 115 membrane at 120 °C and 1000 psi for 3 min to transfer the catalyst layer from the PTFE films to the Nafion 115 membrane [2]. Single cells were constructed with PTFE-treated carbon paper and non-treated carbon paper for cathode and anode, respectively. Active area of the single cells was 4 cm^2.

The single cells were operated at 55 °C. Operation of the cells was carried out at a constant current condition of 100 mA/cm^2. Flow rate of methanol (1 M) and oxygen was 1 ml/min and 100 cc/min, respectively.

3. Results and Discussion

Figure 1 shows the I-V measurement results with operation time. The power density decreased linearly with operation time, however, after operation for 912 hours, no significant change was shown upto operation of 1176 hours. Maximum power density decreased from 62.9 mW/cm^2 to 55.6, 49.2, 40.6, 35.2, 27.6 and 26.3 mW/cm^2 with increasing operation time from 0 to 120, 240, 432, 720, 912 and 1176 hours, respectively. Figure 2 shows operation time vs. ln(maximum power density) graph. Linear fitting was obtained from the figure 2 and we could calculate that the power density will be zero after operation of 5400 hours. Half-life of the single cell was about 910 hours. Figure 3 shows the XRD results for (a) cathode and (b) anode catalysts. From the XRD results, average particle size was calculated. For the anode PtRu catalyst, average particle size increased from 3.3 nm to 3.9 nm after operation. For the cathode Pt catalyst, average particle size increased from 8.3 nm to 9.1 nm. In the case of anode PtRu catalyst, peak shift was observed from 40.4 ° to 40.0 °, which indicates that the Ru was dissolved and the phase was changed towards Pt-only phase (39.6 °).

4. Conclusion

Performance degradation of a DMFC with operation time was observed at a constant current density of 100 mA/cm^2. Rate of degradation decreased with increasing operation time. From the relation between maximum power density and operation time, half-life was calculated to be 910 hours. Particle size change was analyzed by XRD experiment and increase of particle size was observed for both the anode and cathode catalyst. Ru dissolution was also observed.

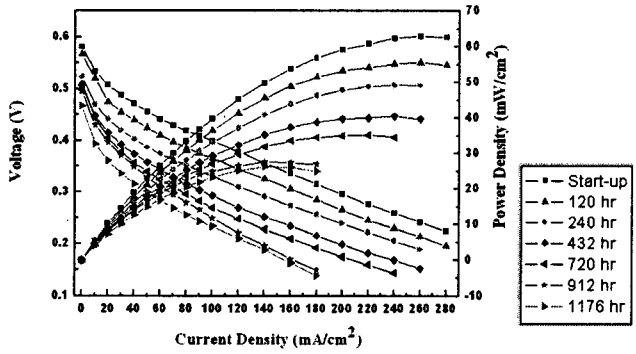

Figure 1. I-V measurement results with operation time.

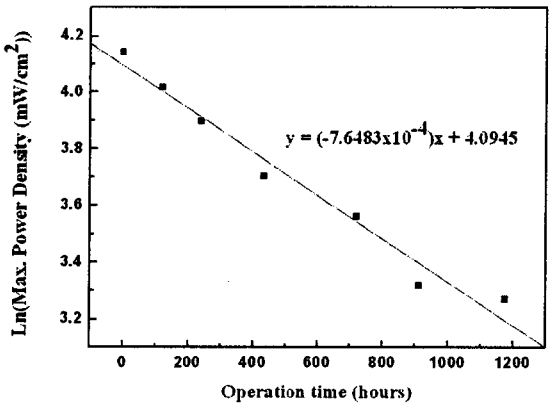

Figure 2. Dependence of maximum power density on operation time.

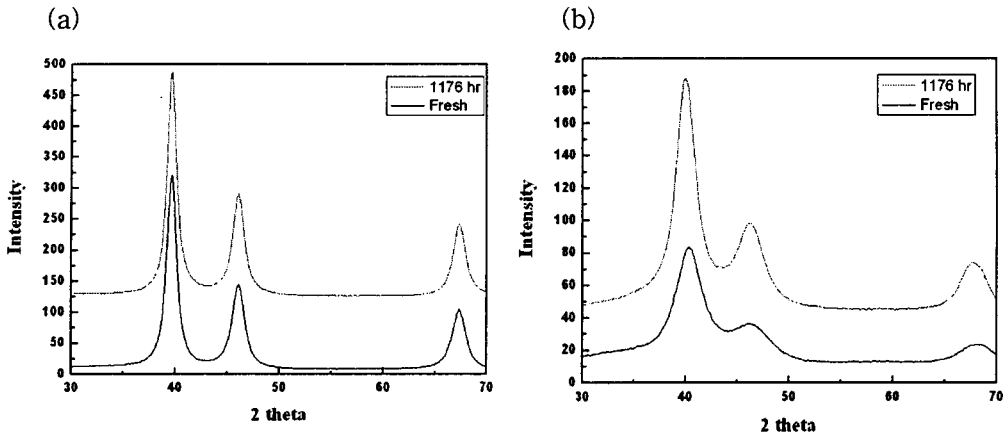

Figure 3. XRD results of (a) cathode (Pt) and (b) anode (PtRu) catalysts before and after operation.

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