Anode Products of A Direct Ethanol PEM Fuel Cell in A Circulating Fuel Operation Mode

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1. Introduction

Recently, several studies of a direct type polymer electrolyte membrane (PEM) fuel cell using ethanol as a fuel have been reported [1-3]. Ethanol has advantages that it is not toxic for human and it is made from biomass. From the viewpoint of practical use, fuel is circulated in a system, although there are no studies that report an effect of fuel circulation. We run the system with circulating fuel to investigate anode outlet products formed during long time operation. This is the first study of direct ethanol PEM fuel cell showing the distribution of anode products quantitatively.

2. Experimental

Membrane electrode assembles (MEAs) consisting of a PtRu anode catalyst (Pt loading: 2mg cm^{-2}, Ru loading: 1mg cm^{-2}), a Pt cathode catalyst (Pt loading: 2mg cm^{-2}) and a Nafion115® membrane as a polymer electrolyte were made by Electrochem Co. The cell was operated at 80 ^{o}C at a constant potential of 0.3V and 0.05V to investigate anode products. The concentration of an ethanol aqueous solution used for the operation was 0.5 mol dm^{-3} (M), and the flow rate of the fuel was set at 5.0 ml min^{-1} with no backpressure. As a cathode gas, humidified oxygen was supplied with a flow rate of 50 ml min^{-1} and no backpressure. As shown in Figure 1, an ethanol solution with anode liquid products was circulated in the system. Anode gas was separated from the liquid-gas mixture and collected in an anode gas trap to analyze the gas products. The anode gas and liquid products were analyzed using a gas chromatograph (Shimadzu GC-8AIT) 1 hour, 4 hours and 7 hours later from the beginning of each operation.

3. Results

An I-V curve and a power density curve are measured to investigate the basic feature of the system as shown in Figure 2. The observed limiting current density and the maximum power density are 50 mA cm^{-2} and 3.5 mW cm^{-2}, respectively. Figure 3 shows the distribution of the anode liquid products depending to the operation time. The main product is acetaldehyde and no acetic acid is observed. The concentration of acetaldehyde at 0.05V is always larger than that at 0.3V and these values increase as the operation time increases at both potentials. The time evolution of the distribution of the anode gas products is shown in Figure 4. The observed products are carbon dioxide and methane. At 0.3V, the mole amount of methane is always larger than that of carbon dioxide, although this relation comes to be contrary at 0.05V. The mole amount of methane decreases as the operation time increases and that of carbon dioxide increases.

References

[1] J. Wang et al., J. Electrochem. Soc., 142, 4218 (1995)
[2] A. S. Arico et al., Electrochem. and Solid-State Lett., 1(2), 66 (1998).
[3] W. Zhou et al., Applied Catalysis B, 46,273(2003)

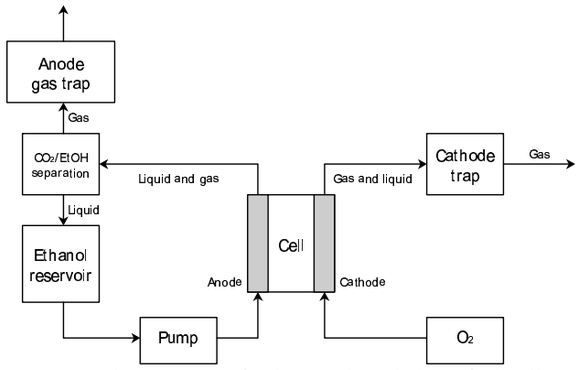

Fig. 1 The concept of a direct ethanol PEM fuel cell system run in this study. An anode gas is separated from gas-liquid mixture and stored in the trap. Ethanol-oxide mixture not fully oxidized and returned from the cell is reused as a fuel.

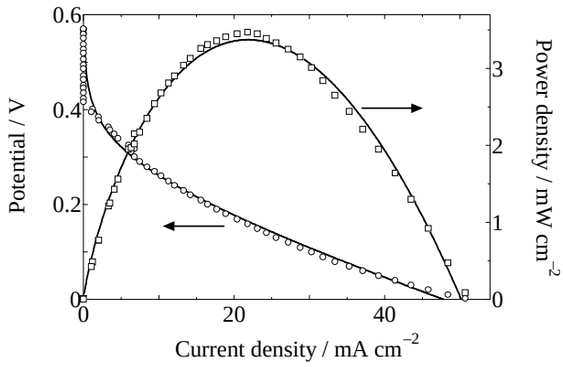

Fig. 2 I-V curve and power density curve. Ethanol concentration: 0.5M, cell temperature: 80 ^{o}C, maximum power density: 3.5 mW cm^{-2}.

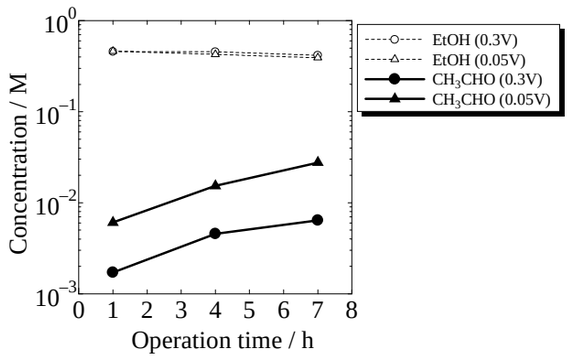

Fig. 3 Time dependence of the concentrations of anode liquid products.

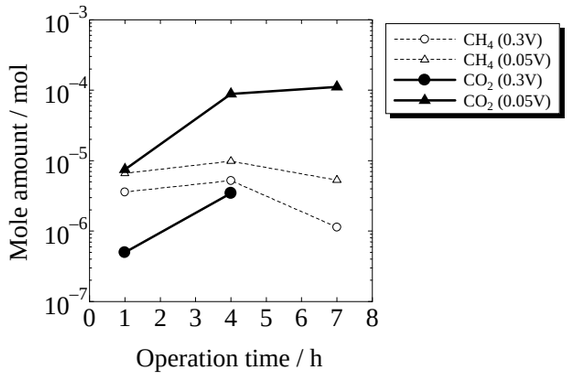

Fig. 4 Time dependence of the mole amounts of anode gas products.