

Analysis of 2-Propanol Electrochemical Oxidation Mechanism on Anode in Direct Alcohol Fuel Cell

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1. Introduction

Fuel cell is expected as one of promised technologies for reducing carbon dioxide (CO₂) emission. Especially, direct alcohol fuel cell (DAFC) is suitable for portable power applications because liquid fuel like methanol can be fed to the DAFC without a reformer. Besides use of the liquid fuel is profitable in terms of energy density per its volume as compared to gas fuel like hydrogen. Recently, it was reported that 2-propanol showed a higher cell voltage than methanol in DAFC at relatively low current density¹⁾. Since high current density do not need in case of mobile instruments like laptop PC or cellular phone, 2-propanol is a potential fuel. Additionally the fuel cell should be operated at room temperature for the actual mobile application. Therefore, the electrochemical oxidation of 2-propanol on anode was investigated in this study

2. Experimental

The experiments were performed using Pt catalyst dispersed on activated carbon (TANAKA-Kikinokoku) as a working electrode. The counter electrode consisted of a platinum mesh and the reference electrode was an Ag | AgCl electrode. Solutions were prepared with Milli-Q water, reagent H₂SO₄, methanol and 2-propanol (WAKO Pure Chemical Inc.). The electrochemical cell was purged using 99.9995% Argon for 10 minutes with stirring. The electrochemical measurements were conducted using a FG-02 and POTENTIOSTAT/ GALVANOTSTAT 2000 (TOHO Technical Research). The potential was converted into hydrogen electrode standard (SHE). For measurements of potential scan, and the electrode was held at 300mV (vs. SHE) for 10 minutes, and then the potential was raised to 650mV with 0.5mV/s. As to the cyclic voltammetry, the cell was held at 450mV in the H₂SO₄/2-propanol solution at proper temperatures for 30 minutes and soaked with Milli-Q water. Then the cyclic voltammetry was conducted in 1.0M H₂SO₄ solution with 50mV/s sweep rate between 0 and 1300mV at several temperatures.

3. Results and Discussion

The pseudo steady state I-V curves are shown in figure 1. 2-propanol began to be oxidized at low potential and exhibited large oxidation current below a certain potential as compared with methanol. The lower the temperature was, the wider the range that 2-propanol was superior in the oxidation current to methanol was. The result that indicates that 2-propanol is a potential fuel for the mobile instruments in terms of not only the current density but also operation temperature. The oxidation current of 2-propanol, however, fell down in a short time and lowered beneath that of methanol while the cell was held at 650mV as shown in figure 2.

To investigate the phenomena, the reaction of 2-propanol was analyzed by the cyclic voltammetry. According to figure 3, while the peak around 500mV appeared and the oxidation current beyond 600mV increased, the peaks of adsorbed hydrogen between 50 to 400mV shrank. These results would indicate the existence of some adsorbent species on active site of the catalyst. The peak and the increase of oxidation current disap-

peared and the hydrogen adsorption peaks almost recovered after the first potential sweep at 60°C, however, still the peak and the oxidation current remained even after the first sweep and then disappeared sweep by sweep at 25°C. Considering that the adsorbent species resulting from methanol are oxidized around 800mV²⁾, those results imply that the species from 2-propanol adsorb stronger than that of methanol and the oxidation of them at lower potential would be essential to use 2-propanol as the fuel for mobile instruments.

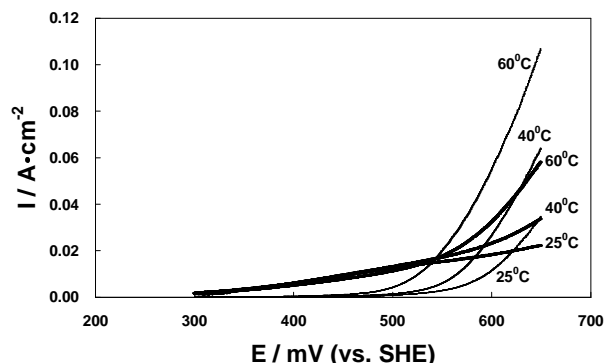


Figure 1. Comparison of pseudo steady state I-V curves between 2-propanol and methanol at different temperatures. Pt:2mgcm⁻², cell size:0.57cm², potential scan rate:0.5mVs⁻¹, temperature:25, 40, 60°C, (—) 1.0M sulfuric acid+2.0M 2-propanol, (—) 1.0M sulfuric acid+2.0M methanol

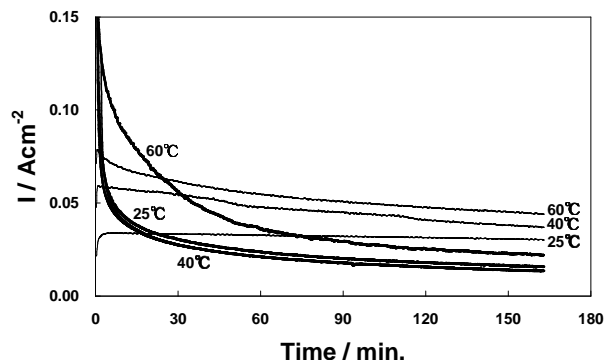


Figure 2. Relaxation of current density at constant potential (650mV), temperature:25, 40, 60°C, (—) 1.0M sulfuric acid+2.0M 2-propanol, (—) 1.0M sulfuric acid+2.0M methanol

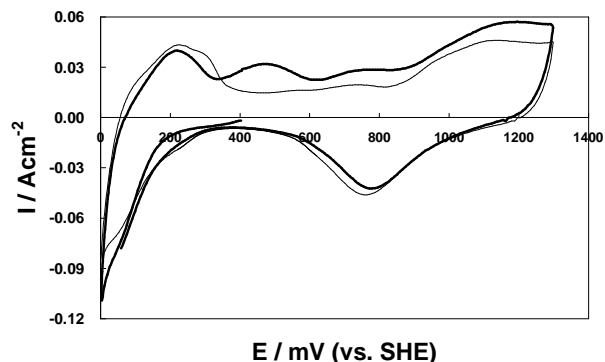


Figure 3. 2-propanol stripping voltammetry, (adsorption) potential:450mV, 60°C, 1.0M sulfuric acid+2.0M 2-propanol, 30min. (stripping): sweep rate:50mVs⁻¹, 60°C, 1.0M sulfuric acid, (—) base voltammogram, (—) stripping voltammogram

4. References

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- 2) S. Wilhelm, T. Iwasita and W. Vielstich, *J. Electroanal. Chem.*, **238** (1987) 383-391