Impedance Analysis of PEMFC in the Presence of Carbon Monoxide

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There is a worldwide interest in the development of polymer electrolyte membrane fuel cells (PEMFC) for vehicular and stationary application. The lowering of the performance is due to the deactivation of the Pt anode catalyst caused by even trace level of CO, i.e. 10-100 ppm [1,2]. Many attempts to understand the mechanism of CO poisoning have been made by the use of electrochemical technique, in-situ infrared spectroscopy and X-ray absorption spectroscopy, etc. [3-5, 6]. In the recent years, impedance spectroscopy has been demonstrated to be a useful experimental technique to examine the complexity of the different processes that take place in fuel cells, and to provide a better insight on the reaction mechanism of electrode system and a systematic investigation of the roles of each parameter plays [7]. The analysis of the impedance distribution in the cell during charging would provide better understanding of the cell performance.

In this study, we prepared a three-electrode membrane electrode assembly (3E-MEA). In the presence of carbon monoxide, the anodic and cathodic impedances were studied individually during the cell discharging. An equivalent circuit model was proposed to explain the results of AC impedance analysis for the anode and cathode.

The catalyst was prepared by impregnation of H_2PtCl_6 and $RuCl_3$ into carbon powder and then reduction with methanol. The sizes of metal particles were in the range of 3~7 nm. The Pt-Ru/C catalyst, mixed with Nafion solution, was then applied onto Teflon-treated carbon paper to be the gas diffusion electrode. The atomic ratio of Ru/Pt was in the range of 0.12~3.3. All of the Pt loadings of the gas diffusion electrodes were fixed to be 0.8 mg/cm^2. A platinum film was deposited on a Nafion 117 membrane to form a Pt/Nafion assembly by impregnation method. The platinum electrode was used as a pseudo-reference electrode. The 3E-MEA was finally made by hot-bonding two gas diffusion electrodes on the both sides of Pt/Nafion assembly. The gas diffusion electrode at the side with pseudo-reference electrode was for anode.

The 3E-MEA was tested with humidified gases. The fuels in this study are neat H_2, H_2 with various CO, and H_2 with various O_2. In addition to the polarization curves of the cell (cathode against anode), the polarization curves of anode and cathode were obtained against the pseudo-reference electrode at the same time. An AC impedance measurements was carried out with an impedance analyzer in the frequency range of 5kHz ~ 10mHz in three-electrode mode. An equivalent circuit model was proposed to explain the impedance spectra for the anode and cathode of the PEMFC. The results of impedances obtained from polarization curves and AC impedance measurement will be compared and discussed.

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