AN INVESTIGATION OF DIRECT METHANOL FUEL CELL DEGRADATION DURING CYCLING OPERATION

MR. NUTTHAPON WONGYAO
ID: 48920004

A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN ENERGY TECHNOLOGY

THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

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Abstract

A cycling operation was conducted to evaluate the effects of direct methanol fuel cell (DMFC) operating conditions on the degradation of electrode and membrane electrode assembly (MEA). Ex-situ methods of X-ray diffraction (XRD), transmission electron microscopy (TEM), and energy dispersive X-ray spectroscopy (EDX) were used to determine the catalyst's particle sizes and compositional change. Also, in-situ methods of frequency response analysis (FRA), and cyclic voltammetry (CV) were used to identify the loss of cell performance during test-time. The MEA performance loss with methanol-oxygen system was investigated and compared between the long-running (LR) and the start-run-stop (SRS) as a cycling operation for 45 h. The maximum cell power density was reduced approximately by 20% and 32% of the initial value after operating under the LR and the SRS modes, respectively. This result corresponded to the anode catalyst agglomeration data obtained from both XRD and TEM analyses with higher increases of PtRu particle sizes under the SRS operation. In addition, the FRA spectra revealed that the anode reaction resistance increased from the initial value of 0.26 Ω/cm^2 to 0.30 Ω/cm^2 after life-testing under the SRS mode for 45 hr. A right-shift of the methanol oxidation peak and a 5.0% reduction of electrocatalyst surface area observed from the cyclic voltammograms also supported this finding. Finally, the decay of cell performance was due to the Ru crossover, as verified by EDX results. Moreover, a 100 h non-stop methanol-air feed system was carried out and the anode dissolution indicated a decrease in the active catalyst area having been caused by Ru dissolution. Cathode performance loss and Nafion® membrane swelling were caused by severe methanol crossover.

Keywords: Direct methanol fuel cell, Cycle operation, Performance degradation, Methanol crossover, Anode dissolution.

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