In-situ observation of the adsorption species on carbon-supported Platinum catalyst in polymer electrolyte fuel cells probed by HERFD-XANES

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Background

Polymer electrolyte fuel cells (PEFCs) have been expected as a clean efficient power source in the next generation and extensively studied to improve both PEFC performance and durability. Carbon-supported Pt nanoparticle catalysts are used as the cathode in membrane electrode assembly (MEA) as an active unit of PEFC. The changes in the electronic structure and chemical adsorption species at the surface of Pt nanoparticles during the PEFC operation are crucial events for the catalytic activity and durability, but their in-situ observations have not been achieved and hence the origin and key factors of the Pt cathode catalysis in the PEFC have not been addressed.

Methods

To investigate these issues, we constructed in-situ hard X-ray emission spectrometers at beamline BL36XU in SPring-8, which enabled to measure high-energy resolution fluorescence detection XANES (HERFD-XANES) of the Pt/C cathode catalyst in PEFC under the operating conditions. Eight sets of spherically bent shape Ge (660) analyzer crystals (R=820 mm) (Saint-Gobain Co.) were installed for the measurements of HERFD-XANES at the Pt L_{III} edge. Two-dimensional pixel array detector (Merlin Quad, Quantum detector Co.) was used for detecting the X-rays diffracted by the analyzer crystals. A PEFC single cell was designed based on the Japan Automobile Research Institute (JARI) standard cell.

Results

We measured the HERFD-XANES spectra at Pt L_{III} edge during cyclic voltammetry (CV) measurement at the cell voltage of 0 -> 1.0 -> 0 V with the scan speed of 20 mV/sec at 80^{o}C. Three distinct peaks were observed in the differential HERFD-XANES spectra depending on the cell voltage. We conducted FEFF calculations of these peaks to clarify the chemical species adsorbed on surface or located in subsurface of Pt nanoparticle.

Conclusion

We developed a HERFD-XANES measurement system for the Pt cathode catalyst in PEFC under the operating conditions. Using this system, we successfully observed the oxygen adsorption species on Pt nanoparticles depending on the cell voltage in situ under the operation of PEFC for the first time.

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