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Investigation of the effect of operating pressure on the performance of proton exchange membrane fuel cell: In the aspect of water distribution

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A B S T R A C T

The effect of operating pressure on the water distribution and its effect on performance of proton exchange membrane fuel cell (PEMFC) was investigated. The experiment was conducted by changing the relative humidity (25%, 100%) and the back pressure value (0.2, 0.4 bar). The PEMFC was either not pressurization, or pressurization on both sides, or on the anode side or on the cathode side. In these conditions, the PEMFC showed higher performance when the cathode side was pressurization than when the anode side was pressurization. The performance difference was analyzed based on the water distribution utilizing X-ray visualization technique. Increase of water saturation in membrane was measured when the cathode side was pressurization at water deficient condition. And the saturation was getting increased as the value of pressure increased. This change caused significant increase in proton conductivity, and performance eventually. At water abundant condition, this phenomenon became weaken and performance difference became narrow. However, increase in pressure on the cathode side increased the air penetration through water and reduced the concentration over-potential. Precedent researches concentrated on the reaction kinetics to analyze the effect of pressure, but the change of water distribution should be considered simultaneously to understand the effect of pressure.

1. Introduction

Fuel cell is a device that generates electricity through the chemical reaction between hydrogen and oxygen. There exist many types of fuel cell depending on the kind of electrolyte. Proton exchange membrane fuel cell (PEMFC) is a kind of fuel cell which uses polymer membrane as an electrolyte. Due to this polymer membrane, PEMFC has distinct characteristics. The operating temperature of PEMFC is relatively low compared to that of other fuel cells. So the product of chemical reaction in PEMFC, which is water, exists as liquid phase in PEMFC. This liquid water, more specifically its distribution within the cell, is one of the most important parameters in PEMFC. Generally, high water saturation in membrane is beneficial to PEMFC. When a proton passes through the membrane, it must react with water and become hydrated. So, higher water saturation in membrane makes higher proton conductivity and the enhancement of performance. On the other hand, low water saturation in gas diffusion layer (GDL) is favorable to PEMFC. To generate electricity through PEMFC, reactant must diffuse through the GDL. However, liquid water in GDL blocks the porous structure and results in low gas permeability. Therefore, for the best performance of PEMFC, it is crucial to analyze the water distribution in PEMFC. In this regard, visualization of water distribution in PEMFC has been conducted by X-ray [1–4], neutron radiography [5,6] and the direct optical method [7,8] to measure the water saturation.

The water distribution in PEMFC can be changed by many parameters such as relative humidity (RH), stoichiometric number of reactant and flow rate. Operating pressure can also change the water distribution, because the water transport in PEMFC is

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