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Measurement of Oxygen Gas Transport Resistance in Cathode Catalyst Layers of PEFC

H. Yasuda, K. Kobayashi, A. Daimaru, M. Hori
Fuel Cell Research Center, Daido University
10-3 Takiharu-cho, Minami-ku, Nagoya 457-8530, Japan

Introduction

Polymer electrolyte fuel cells (PEFCs) are a promising power sources for automotive use. For the commercialization, cost reduction is one of the most important issues. In order to reduce cost, the Pt-loading of a membrane electrode assembly (MAE) should be reduced. Many studies for this purpose have been done.
As a part of such studies, in-situ analytical methods for evaluating oxygen transport properties have been developed using limiting current measurements[1)2)3)]. It has been found that reactant gas transport resistance in CLs (R_{other}) was mainly consisted of two parts, Knudsen diffusion resistance (R_k) and diffusion resistance around Pt particles (R_{Pt}). And it has been found that the diffusion resistance around Pt catalyst R_{Pt} was significantly increased when Pt loading in CLs was reduced[2)].

In this study, the oxygen diffusion resistances in CLs are measured not only the limiting current measurement method but also by the oxygen-nitrogen mutual diffusion method4). The results are analyzed using the difference of oxygen diffusion pass in CLs with these two measurement methods.

Experimental

Table 1 shows the specifications of the MEAs used in this study. The MEA samples with an active area of 1cm^2 were fabricated by coating CLs consisting of catalysis powders (Pt/C) and Nafion® ionomer onto the perfluorosulfonated polymer membrane (Nafion® NR212). Pt-loadings of the samples for the working electrode were 0.50, 0.35, 0.20, 0.12, 0.07 mg cm^{-2} respectively. In order to evaluate the reactant gas transport resistance in the CLs, limiting currents were measured in nitrogen balance gases. R_k and R_{Pt} were determined with the above-mentioned method and were compared[2)3)].

Results and discussions

R_{other} determined by limiting current measurement method is shown in Fig.1. In order to estimate R_k and R_{Pt}, Equation (1) was introduced with the analogy of porous electrode model and value was determined.

$$R_{CL} = \sqrt{R_k R_{pt}} \coth \sqrt{\frac{R_k}{R_{pt}}} L \qquad (1)$$

R_{CL} : Gas Diffusion resistance in CLs
R_k : Knudsen diffusion resistance in CLs
R_{Pt} : Diffusion resistance around Pt catalyst
L : Thickness of CLs

By changing L and measuring R_{other}, the values of R_{pt} and R_k were determined (Fig. 2).
Another oxygen diffusion resistance measurement method which called oxygen-nitrogen mutual diffusion method have been proposed.[4)]
The relation of the limiting current measurement method and the oxygen-nitrogen mutual diffusion method is represented in equation (2)

$$R'_{CL} = R_k \times L \qquad (2)$$

The results are analyzed by this equation.

Table 1.MEA specification

	Counter Electrode	Working Electrode
Catalyst	Pt/C (TEC10E50E, TKK)	
Ionomer	Nafion® (D2020, Dupont)	
Pt loading /mg cm^{-2}		0.50, 0.35, 0.20, 0.12, 0.07
Ionomer /Carbon Ratio		0.7, 1.0, 1.3
Active Area /cm^2	1.0	
Membrane	Nafion® (NR212-CS, Dupont)	
GDL	TGP H060, Toray (without MPL)	

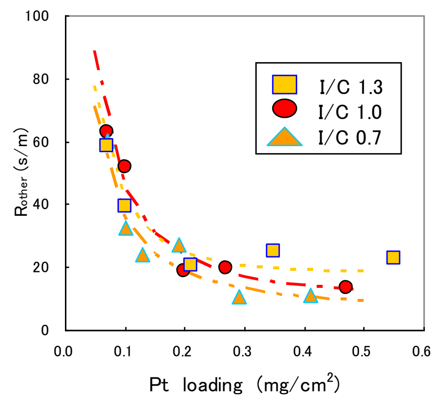

Fig.1 Rother of ORR in the CLs

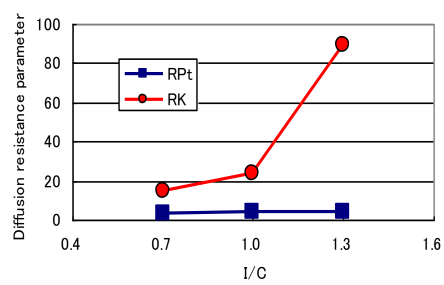

Fig.2 I/C vs Diffusion Resistance Parameters

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