Preparation of High Temperature durable Membrane Electrolytes for PEFCs

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In order to commercialize the PEFCs, much efforts should be focused to develop superior electrolyte membranes, electro-catalysts and separators. The electrolyte membranes should be durable under the temperature higher than 100°C, because the cell is required to be heated in order to perform rapid electrode reaction. However, under such high temperature, membranes are generally dried up unless the system is pressurized. Therefore a new concept is strongly requested to develop electrolyte membranes durable under such severe conditions. In order to fit the conditions, membranes should be wet enough even in such high temperature and another way, is to transfer proton from anode to cathode without extra humidification. Membranes, themselves also should be stable under the high temperature.

In this paper, a room temperature molten salt (RTMS) that transfers protons under the dried condition, is applied to the electrolyte.

As the RTMS, 2-ethyl-imidazolium trifluoroborate (2EtHImBF$_4$) was used. 2EtHImBF$_4$ has high proton conductivity even under the dried condition, however, it is not solid, therefore it should be included in an appropriate supporter. Porous Teflon® was used to make a composite membrane.

Table 1 shows the conditions to set up the fuel cell. Cells 1 and 2 utilized the composite membrane. Cells A and B utilized Nafion® for the electrolyte. In each case, the electrode catalysts were coated by the electrolyte.

The performance of Cells A and B that utilize Nafion® for the electrolyte were too poor under the operating condition with dried gas feed.

The cell performance of Cells 1 and 2 were evaluated under dried hydrogen and oxygen at 100°C and PEFCs operating conditions. As for Cell 1, only a small current was obtained. Since Nafion® has extremely low proton conductivity under the dried condition, there would not be enough proton channel through the MEA.

On the other hand, the cell performance was improved by the addition of 2EtHImBF$_4$ in the gas diffusion electrode, because the proton channels were formed in the electrodes by 2EtHImBF$_4$.

Figure 1 shows the effect of the amount of 2EtHImBF$_4$ added to the gas diffusion electrode on the cell performances. When the quantity of 2EtHImBF$_4$ in the electrode was about 5 vol.%, the cell had the maximum current density at 0.3V.

Table 2 shows the performance of the cell with the RTMS analyzed by the AC impedance method. It is evident that a resistance of an electrolyte and the resistance of hydrogen oxidation reaction is rather small, while that of oxygen reduction reaction is far larger, which would be the main reason for the low cell performance.

Table1 Materials of electrodes and electrolytes.

	Anode	Electrolyte	Cathode
Cell 1	Pt/C, Nafion®	2EtHImBF$_4$/Teflon® composite membrane	Pt/C, Nafion®
Cell 2	Pt/C, Nafion®, 2EtHImBF$_4$		Pt/C, Nafion®, 2EtHImBF$_4$
Cell A	Pt/C, Nafion®	Nafion®117	Pt/C, Nafion®
Cell B	Pt/C, Nafion®		Pt/C, Nafion®, 2EtHImBF$_4$

2EtHImBF$_4$ itself has a high proton conductivity, therefore it is necessary to arrange the condition of the interface of the electrode and electrolyte appropriately.

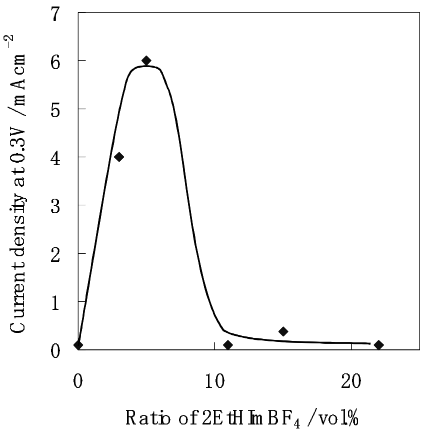

Fig. 1 Current density vs. 2EtHImBF$_4$ ratio in catalyst layer (vol%), 100°C, dry H_2/O_2, V_{cell}=0.3V.

Table 2 Resistance for electrode reactions.

	Cell B	Cell 2
R_H	9.4Ω	10.9Ω
R_O	1700Ω	1400Ω

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