## A Novel Analysis Method of MEA and Evaluation of Newly Developed Fibril Reinforced Membranes for PEMFC

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### Introduction

We have developed a novel MEA analysis method for Proton Exchange Membrane Fuel Cell (PEM FC).
The cell voltages were firstly analyzed by quantitatively determining the activation overpotentials, concentration overpotentials and ohmic losses. The effects of the PTFE fibril reinforced membrane and catalyst coating ion exchange polymers on the cell performances were clarified.

### Princeple of the Novel Analysis Method

The cell voltage-current density relationship of the PEM FC is expressed as follows, if the overpotentials of the anode are neglected.

Cell voltage = $E_0 - (\eta_{act} + \eta_{conc}) - iR$ (a) where

$E_0$ :Theoretical cell voltage
$I$ :current density( apparent )
$\eta_{act}$ : activation overpotential at the cathode
$\eta_{conc}$ : concentration overpotential at the cathode
$iR$ : ohmic loss

The relationship between *iR* free cell voltage and logarithm of the current density is expressed in Fig.1.
If we define the *iR* free cell voltage on the Tafel line as the “Tafel value” at a fixed current density, then the concentration overpotential $\eta_{conc}$ at a fixed current density, for example 1A/cm$^2$, can be obtained by the difference between the *iR* free cell voltage and the “Tafel value” at 1A/cm$^2$. The activation overpotential can be determined by subtracting *iR* free cell voltage from $E_0$.

### Results and Discussion

***1. Effects of the newly developed PTFE fibril reinforced membrane, Flemion FR30®***

Fig.2 shows the cell performances of the MEAs with Flemion®FR30 (30 $\mu$ m) and Flemion®SH50(50 $\mu$ m). The cell voltage analyses of these MEAs are listed in Table1. It was found that the $\eta_{conc}$ of Flemion®FR30 at 1.8A/cm$^2$ is 60mV smaller than that of Flemion®SH50, which is attributed to the increased water back diffusion from the cathode to the anode through the membrane.

***2. Effects of the catalyst coating ion exchange polymer Flemion ® (AR1.1)***

Fig.3 shows the correlations between the Tafel values of different Pt loading MEAs at 0.3A/cm$^2$ and the logarithm of Pt catalyst surface areas measured by the cyclic voltammetry. It was found that the Tafel values and the logarithm of Pt catalyst surface areas have linear correlation, if the MEA fabrication method and materials are same. Fig.3 also shows that catalyst coating ion exchange polymer affects the kinetics of oxygen reduction reaction. The MEAs with the Flemion ® polymer, which has higher ion exchange capacity (1.1m.eq/dry g. resin:AR1.1) than Nafion® (AR0.91), have higher cell voltages. This reason will be discussed in terms of oxygen permeability in the ion exchange polymers.

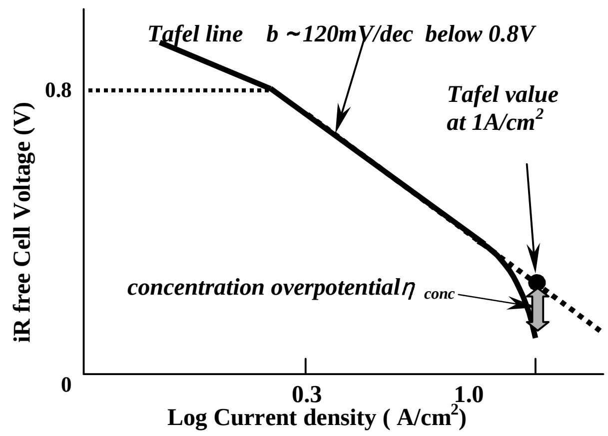


Fig.1 *iR* free cell voltage-current density relationship

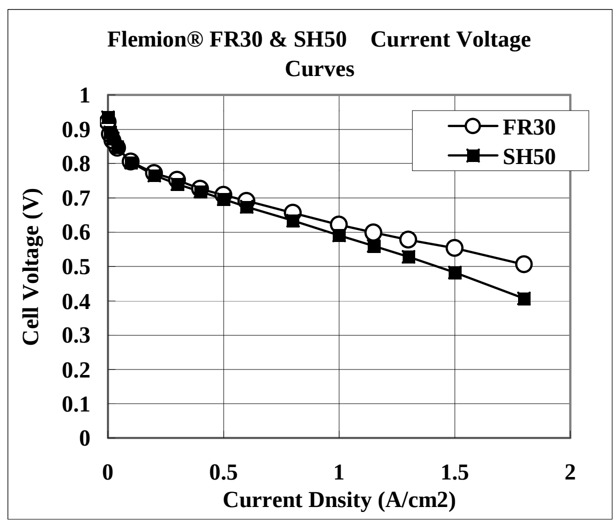


Fig.2 Cell performances of Flemion®FR30 and SH50

| 1.8A/cm$^2$ | membrane | | Δ (mV) |
|---|---|---|---|
| | FR30 | SH50 | (FR30-SH50) |
| Cell Voltage(mV ) | 510 | 410 | +100 |
| Tafel Value (mV ) | 670 | 670 | 0 |
| $\eta_{conc}$ (mV) | 50 | 110 | -60 |
| iR drop (mV ) | 110 | 150 | -40 |

Table1 Cell voltage analyses of Flemion®FR30 and SH50

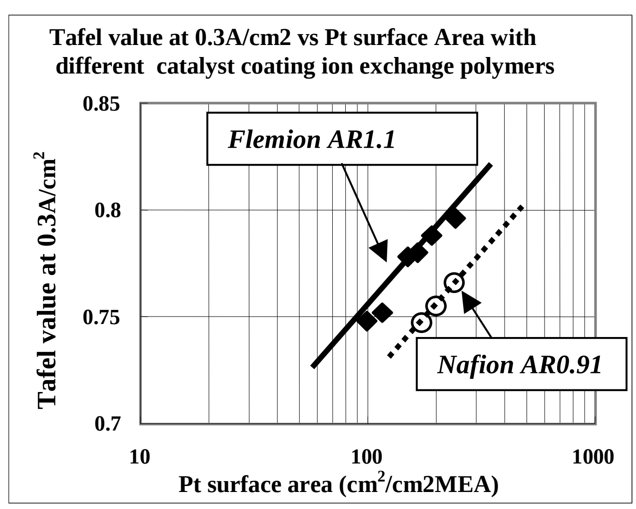


Fig. 3 Effect of the coating polymers on the cell voltages