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In situ EIS studies of PEM fuel cells

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Effect of humidity

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Introduction

In this poster we present the results of an in situ EIS study of low-temperature (H_2/O_2) PEM fuel cells. We aimed at a better understanding of the origin of performance losses at low relative humidity of feed gases. Relative humidity was varied between 90% and 20% RH (&65°C). In situ EIS spectra were recorded at current densities between 100 and 1000 mA/cm² under H_2/O_2 operation.
A simple and adequate equivalent circuit was used to fit the experimental data and extract a number of useful parameters that characterizes the performance of the MEA components.

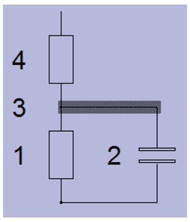
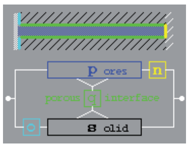
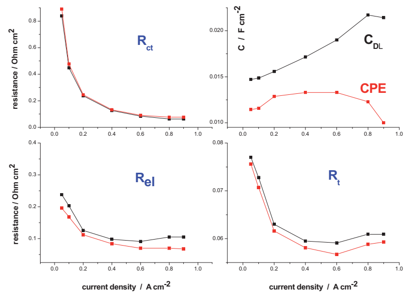


Figure 1 The equivalent circuit used to fit the experimental data.
1 - charge-transfer resistance (R_{ct});
2 - double layer capacitance (C_{DL}, or, alternatively, constant phase element, CPE, can be used);
3 - porous electrode model for a system of homogeneous pores;
4 - total ohmic resistance of the cell (R_t). The contribution of the anode side was neglected.



Porous electrode model for a system of homogeneous pores (H. Göhr)
n – interface code number (=1,2,3, or 4)
p – integral pore electrolyte resistance / Ohm
s – integral solid bulk resistance / Ohm

Figure 4 Effect of the current density on the cell polarization resistance (R_{ct}), resistance of ionomer in catalytic layer (R_{el}), total ohmic resistance (R_t), and double layer capacitance (C_{DL}) or, alternatively, CPE. Black lines show the trends observed for equivalent circuit that included capacitance, whereas red line show the results for the circuit that included CPE, to describe the capacitive behavior of the electrical double layer. (MEA and exp. conditions: same as indicated in figure 2).



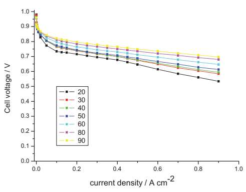
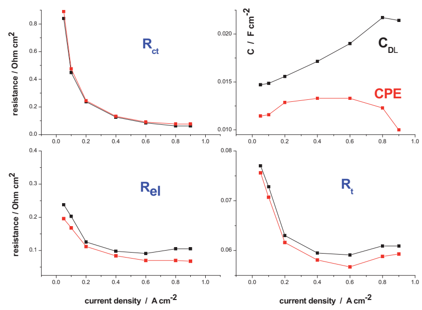


Figure 2 The performance curve recorded at different values of RH(%) for the MEA investigated in this work. MEA: GDL-SGL31BC, mem.-N112, HiSPEC 4000 (0.34 mg/cm² Pt on both A&C); H_2/O_2 operation; 1 atm; 65°C. Numbers in the legend indicate the relative humidity in % at 65°C.

Figure 5 Effect of the relative humidity on the cell polarization resistance (R_{ct}), resistance of ionomer in catalytic layer (R_{el}), total ohmic resistance (R_t), and double layer capacitance (C_{DL}). (MEA and exp. conditions: same as indicated in figure 2)



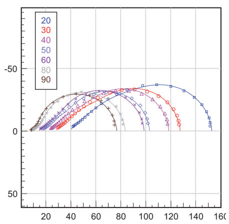


Figure 3A The effect of relative humidity on the in situ EIS spectra recorded at 100 mA/cm². Numbers in the legend indicate the relative humidity in % at 65°C. (MEA and exp. conditions: same as indicated in figure 2)

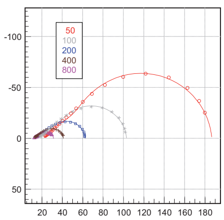


Figure 3B The effect of current density on the in situ EIS spectra recorded at a constant value of relative humidity (50% at 65°C). Numbers in the legend indicate the current density in mA/cm². (MEA and exp. conditions: same as indicated in figure 2).

Concluding Remarks

- •The model proved adequate to describe the system response in a wide range of current densities (50-800 mA cm^{-2}) and RH values (20-90%), although the quality of the fit was poorer at very low RH values (20-30%) or very low current densities
- •Decrease of the relative humidity has a strong negative effect on the ohmic resistance of the cell and the electrolyte resistance in the catalytic layer, whereas the charge transfer resistance is affected at low RH values only.
- •The resistance of the electrolyte in the catalytic layer rises somewhat faster than the ohmic resistance with decreasing dew point. Therefore, the ionomer in the electrolytic layer seems more sensitive to the RH value.
- •Choise of the element for describing the double layer (C_{DL} or CPE) does not affect significantly the values of other fitting parameters. Use of CPE will improve quality of the fit, but will also brings about an underestimation of the cell capacitance.