Investigation of Mass-Transport Limitations
in the Solid Polymer Fuel Cell Cathode

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Introduction

The efficiency of Solid Polymer Fuel Cells (SPFCs) is limited by the slow kinetics of the Oxygen Reduction Reaction (ORR). The knowledge of the mass-transport phenomena limiting the reaction rate of the cathode is therefore important in order to optimize the utilization of the noble catalyst. The experimental procedure used in this work[1] and the analysis of the experiments with a 1D agglomerate model[2] gave new insights into the functioning of the state-of-the-art SPFC cathodes.

Experimental

The electrochemical behaviour of the cathode was studied in-situ in a SPFC by polarizing versus an hydrogen reference electrode at a low sweep rate (less than 0.1 $mV.s^{-1}$). For each potential, the iR-drop was measured with the current-interrupt technique (Fig.1). The structure was investigated by porosimetry and electron microscopy techniques. The modeled curves were fitted to the experimental ones to give the parameters of the ORR kinetics and oxygen diffusion.

Results

The effects on the cathode polarization curves of the active layer thickness, oxygen pressure and humidity of the gas were investigated. The polarization curves consists in a kinetic Tafel slope at low current density, followed by a second slope at higher current density. The second slope has a value close to twice that of the kinetic Tafel slope. This effect is predicted by the model[2] if either of the two following limitations occur in the cathode: proton migration, or oxygen diffusion in agglomerates. A limitation by proton migration could be ruled out since, in both Tafel slope regions, the increase of the current density was observed to be linear with both the oxygen pressure and the cathode thickness (Fig.2). A high relative humidity is beneficial for the cathode since it modifies greatly the parameters of the ORR kinetics (Fig.3).

Conclusions

A reference electrode and the correction for the iR drop is necessary to study the cathode in the SPFC.

A Tafel slope at low current density and a second Tafel slope at higher current density was observed on all polarization curves.

The experimental results correspond to a limitation by oxygen diffusion in the agglomerates.

Acknowledgements

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References

1. J. Ihonen, F. Jaouen, G. Lindbergh, A. Lundblad, G. Sundholm, submitted to *J. Electrochem. Soc.*

2. F. Jaouen, G. Lindbergh, G. Sundholm, submitted to *J. Electrochem. Soc.*

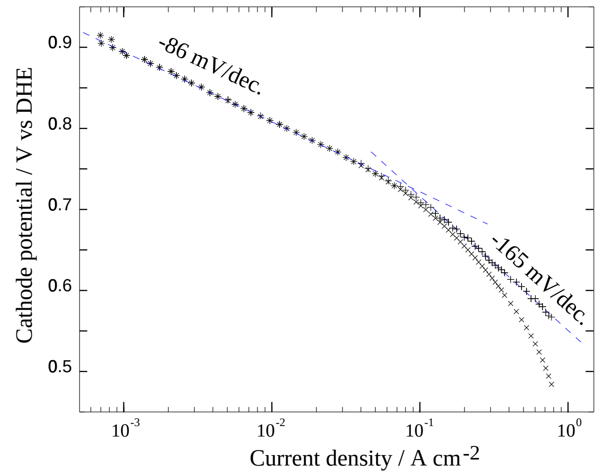

Fig.1: cathode polarization curve, iR corrected (+) and not iR corrected (x).

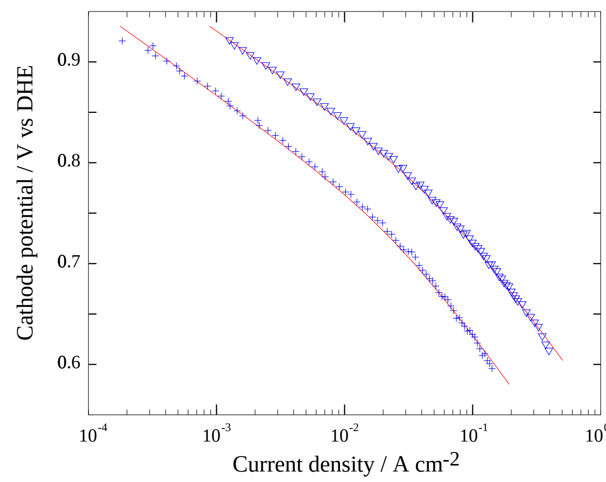

Fig.2: effect of cathode layer thickness. 5 µm (+) and 18 µm (∇). Pure O_2, 60% RH, 1 atm pressure. Line is model fitting.

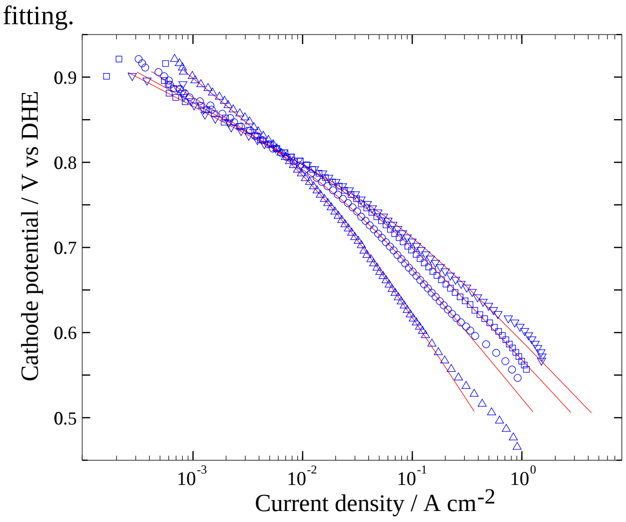

Fig.3: effect of relative humidity. 34% RH (Δ), 60% RH (○), 78% (□), and 90% RH (∇). Pure O_2, 1 atm pressure, 22 µm thick cathode. Line is model fitting.