34th Topical Meeting
of the International Society of Electrochemistry

Spectroscopy Electrochemical Impedance characterization of membranes electrode assemblies for PEM electrolyzers

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INTRODUCTION

Hydrogen is projected as a key energy vector to achieve aspiring global decarbonization goals mainly for those sectors where greenhouse gas emissions are highly challenging to reduce. Therefore, green hydrogen production using water PEM electrolysis has become the aim of numerous recent studies. One of the crucial challenges for improving hydrogen production is reaching a deep knowledge of the role of anodes electrocatalysts. In this investigation we studied and modelled the effect of different anode electrocatalysts and solid electrolyte´s configurations in a single-cell PEM electrolyzer performance, using EIS. We assembled and tested PEM electrolysis MEAs with two different configurations.

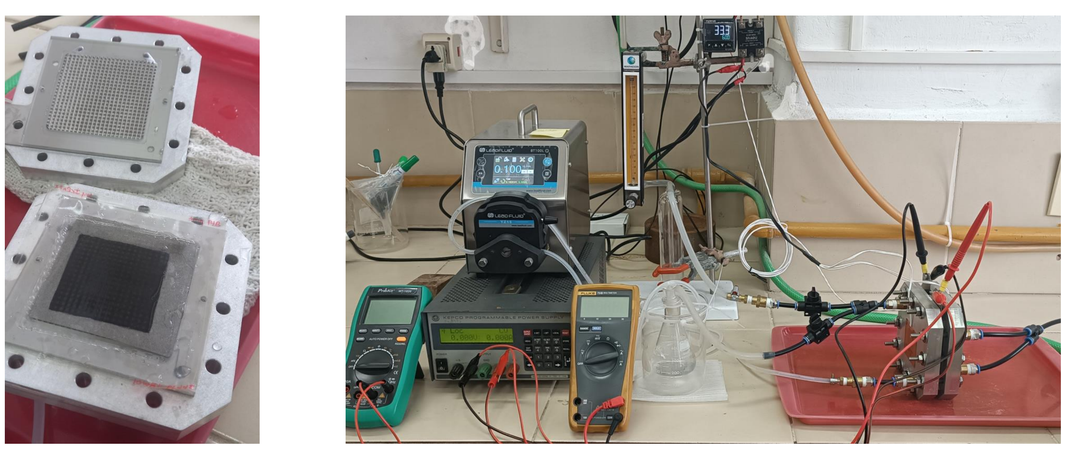

Figure 1. Experimental layout

METHODS

MEA 1 comprises in catalyst-coated membrane (CCM)- type with a geometric area of 25 cm^2 containing Nafion™ 115, 3.0 mg. cm^{-2} IrRuOx as the anode, and 3.0 $mg.cm^{-2}$ PtB for the cathode. MEA 2 involves catalyst-coated membrane (CCM)-type with a geometric area of 25 cm^2 containing Nafion™ 117, and 3.0 $mg.cm^{-2}$ PtB both for the anode and cathode. Sintered Ti plates were used as gas diffusion layers.

After hydration and activation steps, the polarization curve was performed. Hysteresis curves were achieved to provide information on thermal equilibrium during the measurements and stabilize the polarization curve. The construction of the polarization curve was carried out by incrementally increasing the potential from 1.5 V to 4 V, in order to determine the varying points of hydrogen and oxygen production. This was achieved through two techniques: by analyzing the density current vs. applied potential on the electrolyzer and through the measurement of gas flow. The oxygen and hydrogen production rate were measured and compared to theoretical values. All experiments were carried out at 20°C. EIS measurements were performed at different points of the polarization curve, sweeping a frequency range between 10kHz and 10mHz, with an amplitude of 5mV and taking 10 points per decade. To avoid electrocatalysts area effects in charge transfer reaction, time constants were calculated.EIS experimental values were fitted to the equivalent electrical circuit model

RESULTS

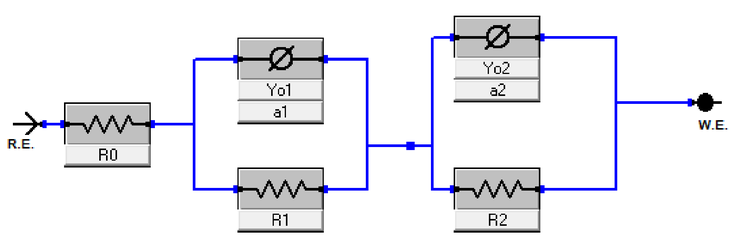

Figure 2. EIS electric equivalent circuit

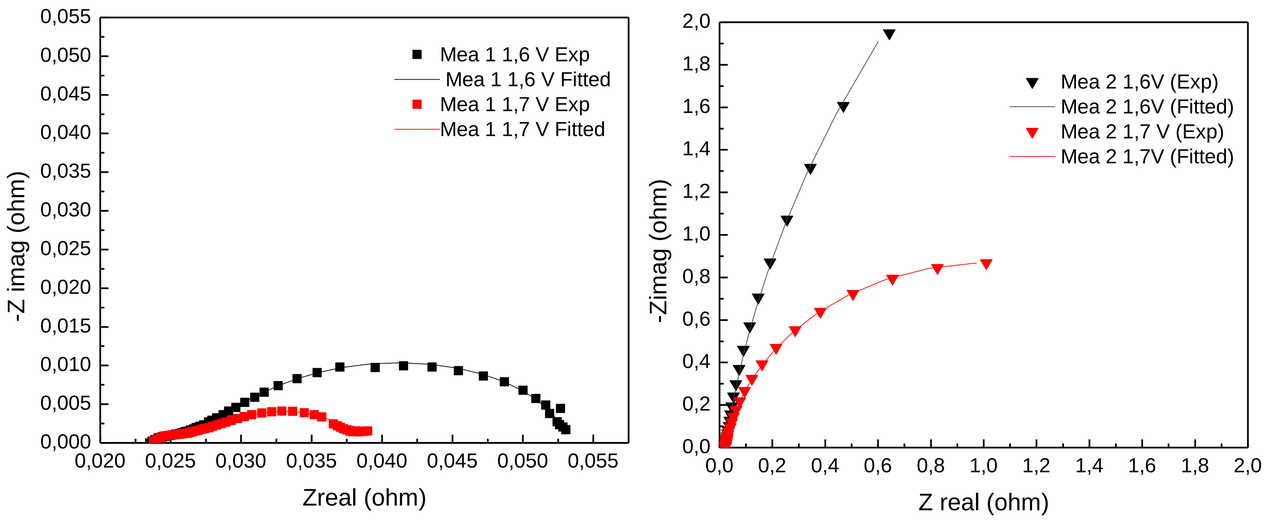

Figure 3. Nyquist plots for MEAs 1 and 2 (experimental and fitted data)

Fitted parameters	1.6V		1.7V	
	Mea 1	Mea 2	Mea 1	Mea 2
Yo_1 (S. s^a)	4.6	42	3.9	12.5
a_1	0.89	1	0.90	0.96
R_0 (mΩ)	23	21	23	21
R_1 (mΩ)	22	116	7.6	114
Yo_2 (S. s^a)	10	0.76	5.4	0.90
a_2	0.42	0.92	0.45	0.91
R_2 (mΩ)	8	11200	7	1900
τ_1 (s)	0.07	4.9	0.02	1.4
τ_2 (s)	-	18700	-	3600

Table 1. ECM EIS Fitted parameters results

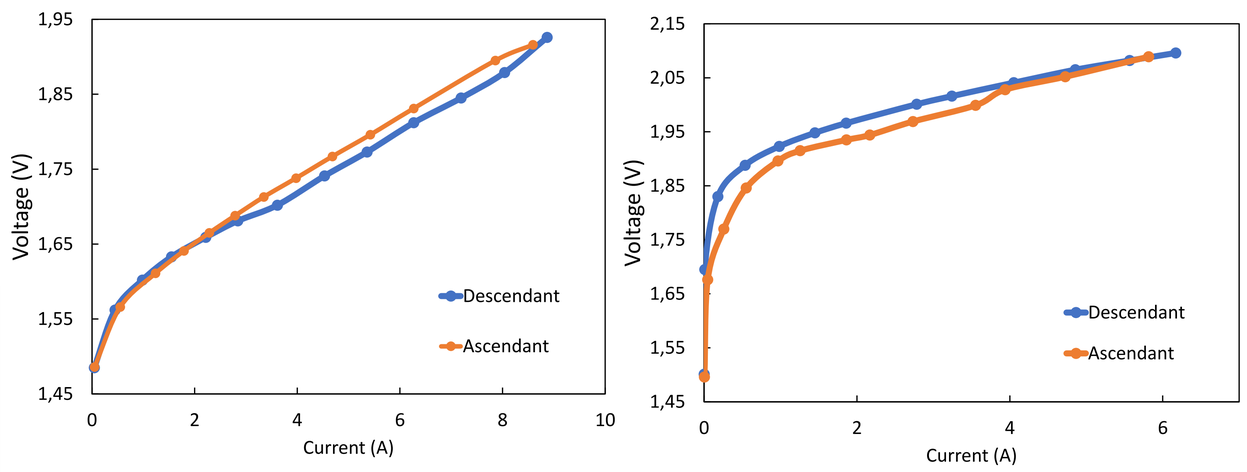

Figure 4. Hysteresis curves for MEAs 1 and 2

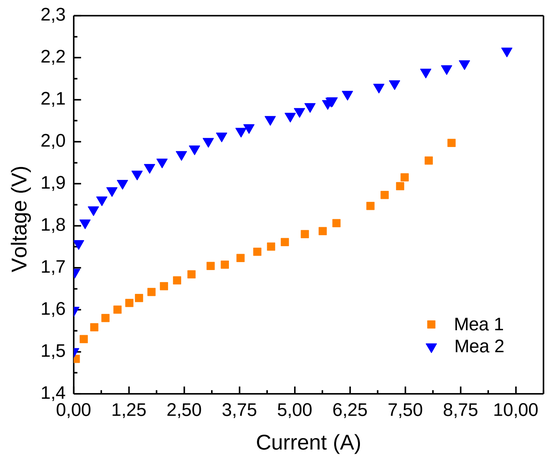

Figure 5. Polarization curves for 20°C

CONCLUSIONS

It can be clearly observed the trend of resistances and overpotentials according to different process control. MEA 1 depicts a2 value associated with diffusion processes. Low onset potential for oxygen evolution reaction depicts for MEA 1 (see Figure 5) means that there will be less power consumption to achieve the same efficiency or same amount of gas generation rate compared to high onset potential case depicted for MEA 2. Best performing catalyst does not necessarily have the longest lifetime. Although different membrane thicknesses would result in different electrochemical performances due to the change in the ionic resistance, for the thickness studied we did not observe a change in the ionic resistance.

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ACKNOWLEDGMENTS

The authors appreciate the supports from CSIC-UdelaR, PEDECIBA and ANII.

C.Z., E.T., and V.D. are researchers at PEDECIBA/United Nations.