PEM water electrolysis with reduced iridium oxide loadings: influence on kinetic parameters and electrolyser performances

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It is expected that PEM water electrolysis (PEMWE) will play a significant role in the hydrogen society as a key process for producing hydrogen from renewable energy sources. But before this, substantial cost reductions are still required. In a PEMWE cell, the oxygen evolution reaction (OER) occurs at high potential values and only few materials (usually platinum group metals) can be used as catalysts to avoid corrosion. In state-of-the-art, pure IrO_2 is generally used as catalyst (with typical loadings of a few mg.cm^{-2}). Reducing the catalyst loading can be achieved either by supporting the noble metal catalyst on a conducting support material; or by adding some inexpensive inert to form Ir-based composite oxide catalyst. However, along with the instability of most of those supports in oxidizing environment[1], the loadings of noble metal on these electrodes are still quite high (1.5-2.0 mg cm^{-2}). According to the literature, iridium loadings can be reduced either by dispersion of oxide nano-particles on conducting support materials like titanium carbide[2], tantalum carbide[3] and doped or reduced form of titanium[4] or tin oxide[5]; or by addition of some inexpensive inert materials such as TiO_2 [6], SnO_2[7] or Ta_xO_2[8] , in order to form Ir-based composite oxide catalysts. However, in addition to the instability of most of these supports in oxidizing environments, iridium loadings on such electrodes remain significantly high (1.5-2.0 mg.cm^{-2}).

The purpose of our study was therefore to evaluate the influence of iridium oxide loadings on the overall performances PEMWE cells and on the kinetics of the OER. To the best of our knowledge, only few studies have been made to evaluate the effect of reduced catalyst loadings. Ma *et al.* were able to reduce the IrO_2 content down to the mg.cm^{-2} scale but they reported significant losses of performances[9].

In order to gain more insights, several MEAs with different anodic catalyst loadings have been prepared and characterized using cyclic voltammetry and impedance spectroscopy, and by measuring polarization curves at different operating temperatures.
The effect of the IrO_2 loadings on the PEMWE performances is shown in Figure 1. Typical cell voltages of 1.72 V have been recorded at a current density of 1 A cm^{-2} (80 °C, atmospheric pressure, using a Nafion®115 membrane) for MEAs with reduced metal loadings (0.25 mg.cm^{-2} of Pt at the cathode and down to 0.5 mg.cm^{-2} of IrO_2 at the anode). Such performances are similar to those obtained with conventional loadings of several mg.cm^{-2}.

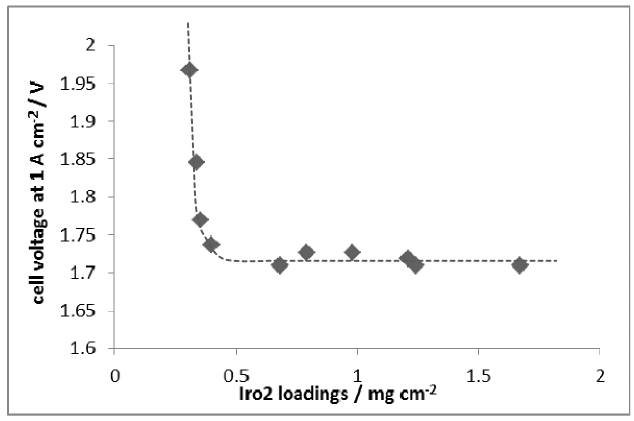

Figure 1: The effect of the IrO_2 loadings in the anode on the performance i.e. cell voltage at 1 A cm^{-2} at 80 °C (atmospheric pressure, using a Nafion®115 membrane and a cathode with 0.25 mg.cm^{-2} of Pt/C).

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