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Development of refractory ceramics for the oxygen evolution reaction (OER) catalyst support for water steam electrolysis.

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A new technique of stability evaluation of ceramic powders was developed. The technique involves dissolution in triflic acid/hydrogen peroxide (TA/HP) mixture at 130 °C and following analysis of dissolved components by inductively coupled plasma mass spectroscopy (ICP-MS). The acid-peroxide mixture is strongly acidic and oxidative, being able to decompose a wide range of chemical compounds. This approach was used to simulate the severe anodic conditions of high temperature PEM electrolyzers and estimate the stability of catalyst support candidates.

It has been shown before, that refractory ceramic powders can be successfully employed as an electrocatalyst support in PEM systems<sup>1,2</sup>.

We have chosen four prospective supports, namely TaC, Si<sub>3</sub>N<sub>4</sub>, Mo<sub>2</sub>B<sub>5</sub> and WB, which were tested for a corrosion stability in TA/HP at 130 °C.

TaC and Si<sub>3</sub>N<sub>4</sub> proved to be reasonably stable, while Mo<sub>2</sub>B<sub>5</sub> and WB were prone to corrosion.

Therefore, the first two compounds were tested as a possible catalyst support for the IrO<sub>2</sub> active phase and their electrochemical performance was evaluated by the thin-film electrode method<sup>3</sup>. The iridium oxide content in the electrocatalyst layer of the electrodes varied from x=0.1 to x=0.9, corresponding to the general formula (1-x)(Support)-x(IrO<sub>2</sub>). The step in compositions was 0.2. The performance of pure IrO<sub>2</sub> electrode was evaluated as well.

The electrochemical performance of catalysts using TaC and Si<sub>3</sub>N<sub>4</sub> supports was evaluated in 0.5M H<sub>2</sub>SO<sub>4</sub>.

Neat TaC powder appeared to have conductivity very close to that of IrO<sub>2</sub>, while the conductivity of Si<sub>3</sub>N<sub>4</sub> was several orders of magnitude lower. However, the conductivity of TaC significantly dropped after introducing it to in-situ synthesis of IrO<sub>2</sub> by the Adams Fusion method.

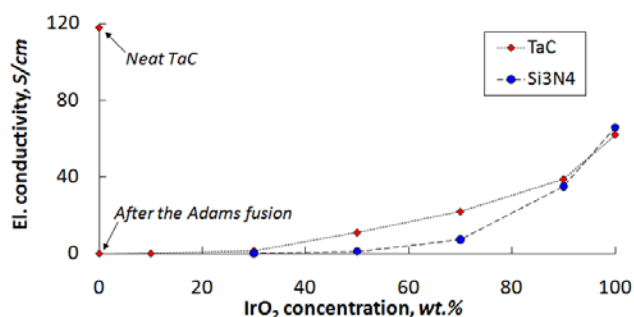


Figure 1. Electrical conductivities of the prepared IrO<sub>2</sub>/TaC, IrO<sub>2</sub>/Si<sub>3</sub>N<sub>4</sub> catalysts and neat TaC support.

Figure 1 shows that conductivity for the supported catalyst decreases with increasing support content, without having plateaus or peaks and, thus suggesting no specific effect on catalyst packing with increasing content of IrO<sub>2</sub>.

At the same time results show the partial surface oxidation of TaC particles during the synthesis, decreasing their conductivity.

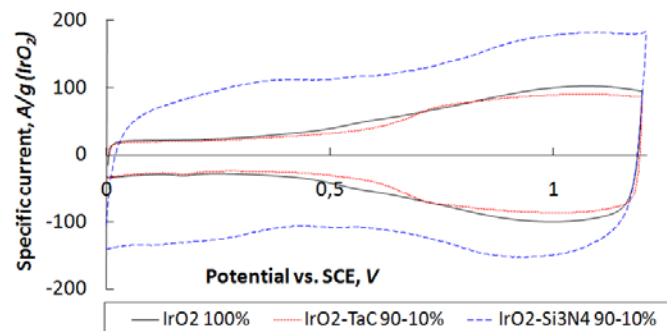


Figure 2. CV results for neat and supported IrO<sub>2</sub>, 0.5M H<sub>2</sub>SO<sub>4</sub>, 500 mV/s

The cyclic voltammetry results shows no decrease of the catalytic activity after introducing supports. Evenmore, using Si<sub>3</sub>N<sub>4</sub>, the total capacitance of the catalyst increased, suggesting an improved arrangement of the active phase on the surface.

<sup>1</sup> Ma L, Sui S, Zhai Y. Preparation and characterization of Ir/TiC catalyst for oxygen evolution. *Journal of Power Sources* 2008; 177(2):470e7. doi: 10.1016/j.jpowsour.2007.11.106.

<sup>2</sup> Antolini E, Gonzalez E. Ceramic materials as supports for low-temperature fuel cell catalysts. *Solid State Ionics* 2009; 180(9e10):746e63. doi: 10.1016/j.ssi.2009.03.007.

<sup>3</sup> Schmidt T, Gasteiger H, Staeb O, Urban P, Kolb D, Behm R. Characterization of high-surface-area electrocatalysts using a rotating disk electrode configuration. *Journal of the Electrochemical Society*, 145:2354–2358, 1998 doi: 10.1149/1.1838642.