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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^{1,2}.

We have chosen four prospective supports, namely TaC, Si₃N₄, Mo₂B₅ and WB, which were tested for a corrosion stability in TA/HP at 130 °C.

TaC and Si₃N₄ proved to be reasonably stable, while Mo₂B₅ and WB were prone to corrosion.

Therefore, the first two compounds were tested as a possible catalyst support for the IrO₂ active phase and their electrochemical performance was evaluated by the thin-film electrode method³. 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(IrO₂). The step in compositions was 0.2. The performance of pure IrO₂ electrode was evaluated as well. The electrochemical performance of catalysts using TaC and Si₃N₄ supports was evaluated in 0.5M H₂SO₄.

Neat TaC powder appeared to have conductivity very close to that of IrO₂, while the conductivity of Si₃N₄ was several orders of magnitude lower. However, the conductivity of TaC significantly dropped after introducing it to in-situ synthesis of IrO₂ by the Adams Fusion method.

Figure 1. Electrical conductivities of the prepared IrO₂/TaC, IrO₂/Si₃N₄ 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 IrO₂.

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 IrO₂, 0.5M H₂SO₄, 500 mV/s

The cyclic voltammetry results shows no decrease of the catalytic activity after introducing supports. Evenmore, using Si₃N₄, the total capacitance of the catalyst increased, suggesting an improved arrangement of the active phase on the surface.

¹ 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.
² 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.
³ 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.