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Iridium-titanium oxide as a stable support for Pt catalyst in PEFC cathodes

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A major drawback for the commercialization of polymer electrolyte fuel cells (PEFC) is the degradation of the cathode catalyst layer. In automotive PEFC applications, the cathode potential can reach values up to 1.5 V during start/stop conditions [1-3]. State-of-the-art cathodes made of platinum nanoparticles supported on high surface area carbon suffer from severe corrosion at cell voltages above 1.1 V, because at such high potentials oxidation of the carbon support occurs [1]. The consequence is a detachment of Pt catalyst nanoparticles, and thus a strong degradation of PEFC performance.

One promising approach to overcome the problem of support corrosion is the use of conductive metal oxides instead of carbon as support for the Pt catalyst. Their property of being in a thermodynamically preferred oxidized state makes them good candidates to resist the oxidative environment at the PEFC cathode side. Iridium oxide is well known to have excellent conductivity properties [4]. However, due to the high price of iridium, the development of a mixed oxide on the basis of a less expensive and electrochemically stable carrier oxide containing Ir is foreseen.

We studied the stability and performance properties of Pt nanoparticles supported on high surface area iridium-titanium oxide ($Ir_xTi_{1-x}O_2$) [5] in an attempt to carefully determine the reaction kinetics with respect to both oxygen reduction and evolution reaction, respectively. The electrochemical stability of the bare oxide support and of the supported Pt catalyst was tested by cyclic voltammetry in argon saturated 0.1 M $HClO_4$ using the thin-film rotating disk electrode technique [6] where the catalyst is drop-coated onto the glassy carbon disks as the working electrode. In order to simulate start/stop conditions in PEFC operation, 1000 cycles between 0.5 and 1.5 V versus a hydrogen reference electrode (RHE) were performed. Our results confirm the high stability of the $Ir_xTi_{1-x}O_2$ support material. The activity of the bare oxide support and of the oxide supported Pt catalyst both towards the oxygen reduction reaction (ORR), and towards the oxygen evolution reaction (OER), has been investigated using rotating disk electrode (RDE) measurements in oxygen saturated electrolyte. Furthermore, the reaction pathway has been studied with the rotating ring-disk electrode (RRDE) technique, where the production of hydrogen peroxide during the ORR can be detected. Interestingly, these measurements reveal activity of the bare $Ir_xTi_{1-x}O_2$ support towards the oxygen reduction reaction (ORR) at potentials below 0.5 V vs. RHE. In summary, the high suitability of the $Ir_xTi_{1-x}O_2$ material as a stable support for the Pt catalyst in PEFC cathodes could be demonstrated.

Acknowledgements

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