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Stability of $LaNiO_3$ gas diffusion oxygen electrodes

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Abstract In this work $LaNiO_3$ perovskite-type oxide, prepared by a self-combustion method, was optimized for activity and stability as an anode material for water electrolysis. A full electrochemical study was conducted in order to kinetically characterize electrodes prepared using carbon paper as a base for porous gas-diffusion electrodes in alkaline media, regarding water oxidation and oxygen reduction reactions at room temperature. An electrode stability study was performed by potential cycling and at constant current density, using cyclic voltammetry and electrochemical impedance spectroscopy to check on stability after cycling with complementary scanning electron microscopy/energy dispersive X-ray spectrometry (SEM/EDS) analysis of fresh and degraded electrodes. Comparison was made using nickel foam as a support for $LaNiO_3$ deposition. Carbon instability in the potential region of interest contrasted with the lower contact resistance between the oxide and support of the Ni foam. Higher metal oxide loadings and dimensional stability were also possible.

Keywords Perovskite-type oxides · Electrolysis · Anode materials · Regenerative fuel cells · Gas diffusion electrodes

Introduction

Regenerative fuel cells (RFCs) are promising energy storage systems for uninterrupted power supplies, which can provide very high energy storage at minimal weight, by combining an electrolyzer in which water is converted into hydrogen and oxygen by a primary energy source and a fuel cell. In this way, the recombination of the stored hydrogen and oxygen generates water and electrical energy in a dual mode system. Although RFCs are an appealing technology for meeting these energy needs, their development is still at an early stage. One key issue is the development of highly active electrocatalysts for both oxygen reduction and water oxidation [1–5].

Perovskite-type oxides, with the general formula ABO_3, are potential catalysts for next generation of RFCs. Nickel containing perovskite type oxides have been reported within the most active materials for oxygen evolution reaction (OER) in alkaline media and also with good electrocatalysts properties for the oxygen reduction reaction (ORR) [1]. In particular, $LaNiO_3$ has been recognised as one of the most promising oxygen electrodes.

Electrodes require an optimum design in order to facilitate mass transfer processes, containing apart from the catalytic active layer (CL), a gas diffusion layer (GDL). The latter brings the gaseous reaction media to the catalytically active layers, and at the same time establishes the electrical contact between the CL and the current collectors in the cell; they are often made of a carbon fiber material with a carbon sub-layer consisting of carbon particles and a hydrophobic binder. Gas diffusion electrodes (GDEs) have the advantage of presenting a highly developed three-phase boundary where the electrode reactions take place. GDEs also serve as a carrier of the catalysts ensuring a fast electron exchange reaction and provide a fast transportation of the reactants and the reaction products to and from the three-phase boundary. Usually, carbon black (Vulcan XC-72) is used as catalyst support, namely in PEMFCs. However, carbon black is known to undergo electrochemical oxidation under a fuel cell operating environment, especially at potentials above 0.8 V, with oxidation rate increasing with potential, leading to catalyst loss and fuel cell

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