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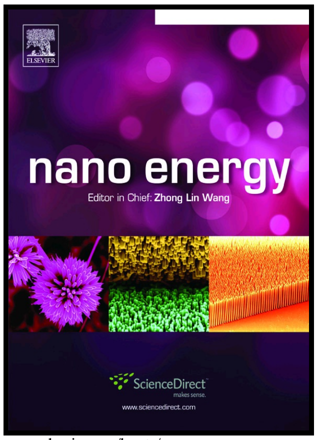

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New insights into the stability of a high performance nanostructured catalyst for sustainable water electrolysis

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ABSTRACT

Water electrolysis is a very promising technology for sustainable hydrogen generation using renewable electrical energy. The excellent performance and dynamic behavior for storing electrical energy in hydrogen allow polymer electrolyte membrane (PEM) electrolysis to cover the gap between the intermittent renewable power production and the grid demand at different time horizons and scales. This work is addressed to the development and characterization of high performance nanostructured Ir-Ru-oxide electro-catalyst achieving for the rate determining oxygen evolution reaction a current density of 3 A cm^{-2} at about 1.8 V (>80% enthalpy efficiency) with a low catalyst loading (0.34 mg cm^{-2}). The stability characteristics were studied in practical PEM electrolysis cells operating at 80 °C, using several durability tests of 1000 h each to evaluate the reliability of this electro-catalyst for real-life operation. Further insights on the degradation mechanism were acquired by subjecting the catalyst to potential steps in a specially designed electrochemical flow cell under corrosive liquid electrolyte with on-line monitoring of the dissolved ions. Structural, morphology, composition and surface analysis of the anode electro-catalyst after operation in the electrolysis cell, complemented by in-situ electrochemical diagnostics, provided important insights into the degradation mechanisms. Catalyst operation at high turnover frequency (TOF) was observed to cause a progressive change of Lewis acidity characteristics with time for both Ir and Ru cations thus influencing their ability to promote water oxidation.

Key-words:

Water splitting, electrolysis, hydrogen, nanostructured electro-catalysts, Ir-Ru Oxide, stability.

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1. Introduction

Hydrogen is widely considered a promising energy vector that can act as a mediator between renewable sources and sustainable mobility [1-4]. As alternative fuel, hydrogen is characterized by proper energy density and clean combustion [5-7]. Its wide spread use will assume in the future an increased environmental and societal relevance to address energy issues, pollution, global warming and related climate changes effects [8,9]. Water electrolysis systems connected to renewable power sources represent a reliable process for an efficient and sustainable hydrogen production to power next generation fuel cell vehicles [10-12]. The most profitable applications for large-scale electrolyzers (MW range) deal with power-to-gas, grid balancing, hydrogen generation for the metal industry and to produce synthetic fuels [10-14]. Among the various water electrolysis technologies, proton conducting polymer electrolyte membrane systems possess the ability to