DEVELOPMENT OF PLATINUM-GROUP-METAL FREE ELECTROCATALYSTS FOR PEM HYDROGEN TECHNOLOGIES

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ABSTRACT

Proton exchange membrane fuel cells (PEMFCs) constitute a promising power- generating electrochemical device with high power density and low emissions [1]. This technology can efficiently convert the chemical energy of hydrogen into electric energy. Hydrogen is ideally produced through water electrolysis, the electrochemical splitting of water. In both technologies, high amount od noble metals are used. Replacing the unsustainable Pt based electrocatalysts used at the electrodes with non-Platinum Group Metals (PGMs) is crucial [2,3]. In this work, interest is focused on the Oxygen Reduction Reaction (ORR) taking place at the cathode of a fuel cell, where higher amounts of Pt are required and the Hydrogen Evolution Reaction (HER) at the cathode of an electrolysis cell. Among the investigated candidates, nitrogen coordinated metals in atomic dispersion (M–N-C catalysts) are promising[3,4]. This work presents in a comparative manner the synthesis, characterization and evaluation of several Fe–N–C materials. More specifically, the strategy involves the preparation and subsequent pyrolysis of hybrid composite materials based on polyaniline and iron (II) chloride tetrahydrate as the iron source, templated onto 1D porous silica-based template derived from naturally occurring halloysite nanoclay. Among other differentiations, the synthetic approach further involves the incorporation of bipyridine as an additional nitrogen source and iron ligand. Pyrolysis conditions (atmosphere, temperature), heat treatment sequence and the initial precursor composition are the key parameters studied in this work. We obtained hierarchically porous structures with high surface area and atomically dispersed iron coordinated with nitrogen. Concerning ORR, their electrochemical performance in 0.5 M H_2SO_4 aqueous electrolyte revealed catalysts having a half-wave potential of close to the DOE 2025 target of 0.85 V (catalyst loading of 0.6 mg/cm^2), mass activity of above 3 A/g and exceptional stability, thus ranking them high among the most promising structures in the literature so far.

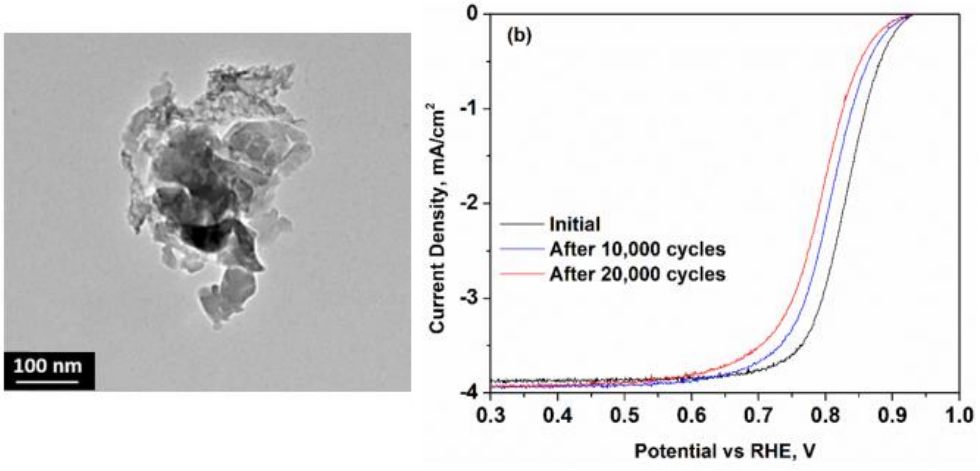

Figure : TEM image and polarization curves of our best performing Fe-N-C catalysts before and after the accelerated stress in oxygen saturated 0.5 M H_2SO_4 at 900 rpm, at room temperature and a scan rate of 1 mV/s. Catalyst loading 0.6 mg/cm^2.

KEYWORDS: PEM fuel cells, non-PGM electrocatalysts, Oxygen Reduction Reaction, accelerated stability test

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