Ni-Fe-S alloy nanostructured electrodes for alkaline electrolyser

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In recent years, renewable energy sources are becoming more and more relevant owing to the progressive decarbonization of energy processes to reduce CO2 emissions [1,2]. In this view, worldwide public authorities are encouraging the use of renewable energies by promoting laws and guidelines [3,4]. One of the main drawbacks of renewable sources is their unpredictability, consequently, interest in green hydrogen has drastically increased. One way to produce green hydrogen is by water electrolysis using only electricity from renewable sources. It is a viable strategy to take advantage of the surplus electricity from them. The most relevant part of the cost of electrochemical hydrogen comes from the electricity cost and catalysts. For this reason, research is focused on improving the performance of the electrolyzer, using more efficient and less expensive materials, such as transition metal alloys like Nickel-based alloy [5].
One way to improve the performance of electrolyzers is based on the development of nanostructured electrodes distinguishing for low cost and high electrocatalytic activity.

The proposed technique for fabricating the electrodes is known as template electrosynthesis. The template used is a commercial porous polycarbonate membrane (PMC - Whatman, Cyclopore, 20 µm thick), which due to its morphology allows the formation of nanowire-shaped nanostructures, highly interconnected with each other, which have the advantage of possessing a high surface area (about two orders of magnitude higher than planar electrode with the same geometric area). To make the membrane conductive, a gold film of thickness around 20-30 nm is deposited on one of the template surfaces by a sputtering process. After sputtering, a compact nickel layer of thickness around 20 µm is electrodeposited on the gold side. This, in addition to ensuring adequate mechanical strength to the electrode, acts as a current collector. After the electrodeposition of the nickel collector, the next step is the electrodeposition of the NWs formed inside the template pores.

In previous works, we have fabricated Ni nanowires by template electrosynthesis, featuring by very high surface area. Starting from the best-performing nickel-iron alloy previously studied [6], this work focuses on the fabrication of nickel-iron-sulfur electrodes. In an aqueous solution containing nickel and iron, a third element is added in different concentrations in order to obtain electrodes with different compositions. The chemical and morphological features of these nanostructured electrodes are carried out through scanning electrode microscopy (SEM) and energy diffraction spectroscopy (EDS) analyses, and those results will be presented and discussed. Subsequently, electrochemical and electrocatalytic tests (Cyclic Voltammetry (CV), Quasi Steady State

Polarization (QSSP) and Galvanostatic Step) are carried to establish the best alloy composition and they are carried out for both hydrogen and oxygen evolution reactions. Then, a long-term test conducted at a constant current density in an aqueous solution of potassium hydroxide (30% w/w) will also be reported.

This work was supported by the Sustainable Mobility Center (Centro Nazionale per la Mobilità Sostenibile—CNMS) under Grant CN00000023 CUP B73C22000760001 Piano Nazionale di Ripresa e Resilienza, Missione 4 - Componente 1/2

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