**Functionalized Cathodic Porous Transport Layers for Alkaline Water Electrolyzer**

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**1.Introduction**

Green H2 production can be carried out through water electrolysis (WE). Currently, among the available technologies the best one is potentially the Anion Exchange Membrane electrolyzer that can exploit the advantages to operate in alkaline environment with the use of an ion exchange membrane as separator [1]. A crucial component of electrolyzers is the Porous Transport Layer (PTL) that is needed to have an efficient mass transport of both reagents and products (in liquid and gaseous phase), to connect the catalyst layer with the bipolar plate and to support the membrane that can operate with high differential pressure.

In alkaline environment Platinum Group Metal (PGM) free catalysts can be used. Especially at the cathode of the electrolyzers, where oxidating conditions are not present, Ni foams are typically used as PTLs. However, even unexpensive stainless steel mesh (cost < 10 €/m2) can be used as PTL but they need a functionalization process to have suitable catalyst layer for efficient H2 evolution reaction (HER).

In this work we present functionalized stainless steel mesh as suitable and reliable PTL for alkaline electrolyzer. Functionalization process was carried out by electrodeposition in a suitable electrolyte to make a Ni, Cu and Mo-containing catalyst layer [2]. Electrodeposition operating parameters, such as electrolyte composition, cell potential and operating time were optimized to minimize the applied overpotential for the HER reaction.

**2. Methods**

Stainless steel AISI 304 mesh were used as PTLs. Mesh samples were polished in 0.5 M H2SO4 with an ultrasonic bath. Then, they were functionalized through an electrodeposition process where they were polarized at different potentials (ranging between -1 and -2 V) for different times (ranging between 3 and 10 min) in a three electrode setup with a Pt mesh as counter electrode and a Ag/AgCl/3.5 M KCl electrode as reference electrode. Electrodeposition bath was an aqueous solution containing NiSO4, CuSO4, H3BO3 and (NH4)6Mo7O24. Electrolyte pH was corrected with H2SO4 to maintain pH values under 3.

Characterization was carried out in 1 M KOH by using the same three electrode setup used for the functionalization process. Electrochemical Impedance Spectroscopy and Differential capacitance measurements were carried out in the same electrolyte.

**3. Results and discussion**

Overpotential vs current density curves, as a function of Mo content in electrodeposition bath, are reported in Figure 1.



**Figure 1.** Overpotential vs current density curves as a function of Mo content in electrodeposition bath.

In the case of bare stainless steel mesh, overpotential at 100 mA cm-2 is about -610 mV. It is noteworthy to mention that the operating typical current density value for electrolyzers is 100 mA cm-2. After the functionalization process, the overpotential is reduced to -260 mV. This result can be explained by taking into account the effect of Ni presence, in terms of higher catalytic activity (i.e. higher exchange current density), and the effect of Cu presence, in terms of weakening of H-adsorption on catalyst layer. Differential capacitance measurements confirmed that there is also an effect in terms of higher electrochemical surface active area. By optimizing the content of Mo in the electrodeposition bath, we further minimized the overpotential, reaching -160 mV. In order to study the kinetics of HER reaction, we also performed Electrochemical Impedance Spectroscopy measurements. Impedance spectra were modeled with a suitable equivalent electrical circuit obtaining the exchange current density value for each sample. Stability tests were carried out, reaching 6 hours without any sign of degradation of catalytic performances.

**4. Conclusions**

In this work we have prepared PTLs for H2 production in alkaline environment by electrodeposition process on stainless steel mesh. Overpotential was reduced by optimizing operating parameters of the functionalization process, such as applied voltage, operating time and electrodeposition bath composition. Results are promising to take into account the cheapness of the stainless steel mesh with respect to typical Ni foams that are used as PTLs in electrolyzers. Further investigation are needed in order to test the PTLs in a flow through cell configuration.

**References**

1. C. Santoro et al, ChemSusChem (2022), https://doi.org/10.1002/cssc.202200027.
2. Y. Li et al., Nat. Communications 11:2720 (2020).