ITI HiFunMat Master Internship Proposal

☒ M 1 ☒ M 2

Title: Development of Ni@CrO_x electrocatalysts for the hydrogen evolution reaction

Internship supervisor

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Laboratory	Institute for Chemistry and Processes for Energy, Environment and Health (ICPEES) Electrochemistry and energy conversion team
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Elena R. Savinova

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☒ Chemistry ☐ Physics
Other indications if necessary	

Internship description

This internship is a part of a project that aims to develop an alkaline membrane electrolyzer in which the catalytic materials exclude costly elements such as Pt, Ir, etc. Specifically, we focus on the design of the cathode's catalytic materials, where the reaction to reduce water to H_2 (*i.e.,* hydrogen evolution reaction – HER) takes place. Currently, Ni@NiO_x heterostructured materials are considered one of the most promising non-noble metal catalysts for said reaction[1]: while metallic Ni has rather poor HER activity (Ni strongly adsorbing H), the presence of an optimal surface coverage in NiO_x substantially increase its activity. However, this NiO_x phase is not stable in the reducing HER conditions, leading to a gradual decrease of the electrocatalytic activity. This can be addressed by preparing an alloy made of NiCr (*e.g.* Ni/NiO-Cr_2O_3) materials. Indeed, Cr_2O_3 phase may act to stabilize the NiO_x during its operation, allowing the catalyst to retain the enhanced HER activity from synergistic Ni/NiO_x surface sites [2].

Considering this, the internship aims at the development of carbon-supported Ni@CrO_x composites, to (i) achieve high HER initial performance, owing to an optimized state of the electrode surface and (ii) maintain this high performance over extended periods of operation.

The student will develop alloys made of nickel and chrome via electrodeposition, first supported on a low-surface area glassy carbon electrode and then on a high surface area carbon black, and characterize their activity for the HER, as well as their stability during said reaction. The electrodeposition conditions will be optimized to finely tune the nanostructure shape and composition, using feedback from physicochemical (SEM, TEM, XPS, *etc.*) and electrochemical methods. The latter will include experimental determination of the HER kinetics (using voltammetry, impedance, etc.) and the effect of excursions at high/low potential on the surface chemistry, with a special attention to the stability of the surface oxides.

[1] A. G. Oshchepkov, et al. ACS Catal. 2019, 9, 9, 8520–8528

[2] M. K. Bates, et al. J. Phys. Chem. C 2015, 119, 10, 5467–5477