Title of PhD Thesis: *``Electrochemical Energy Conversion Electrode Component and Process Multi-scale Imaging´´*

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Introduction:

Due to the fossil fuel shortage and climate disasters such as global warming, the need for green and sustainable energy is of paramount importance for us. Hydrogen is one of the most interesting alternatives for traditional fossil resources which can be produced by different methods, among which water electrolysis (water splitting) regarded as the cleanest approach[1]. In this method, an external potential is driven to the system to start reaction of splitting water to hydrogen and oxygen molecules. However, because of kinetic loss mechanisms available in the system, an excessive energy (also called as overpotential) should be imposed in the system. One of the most important energy losses in these systems is related to mass transfer through the system and the formation of bubble on the surface of electrodes which can reduce active surface area and consequently worsen electrocatalysis activity.

Methodology/methods:

The catalyst surface is a critical spot in improvement of water splitting performance since it is an interception between solid catalyst, liquid-phase electrolyte and produced gases. Therefore, it has to provide appropriate active sites at the surface for reactant to continue hydrogen production and at the same time diffuse away the dissolved product gas. Different methods have been investigated to increase electrocatalysis activity through the water splitting process, decreasing aerophobicity[2] or increment of hydrophilicity of the catalyst surface, rotating disk electrode and applying a magnetic field[3], to name of a few. Ultrasonic field is also another strategy which can be taken into account to reduce bubble formation at the surface. In this collaboration, we would evaluate the effectiveness of applying an ultrasonic field in electrocatalytic activity.

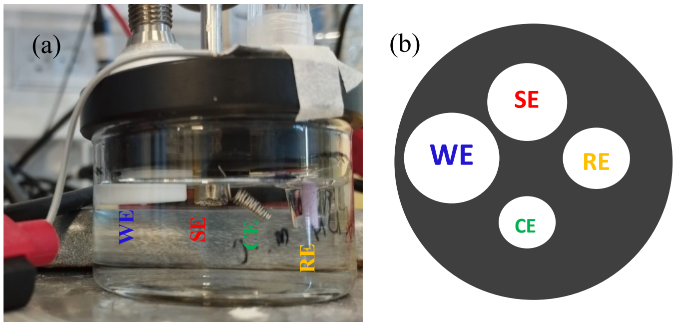

Fig1. a) A picture of the water splitting setup b) A top-view schematic of the position of different electrodes in the setup

WE: working electrode
SE: sonication electrode
RE: reference electrode
CE: counter electrode

Objectives:

Since the bubble creation and mass diffusion is a several scale processes from nano- to micrometer, the use of multi -scale imaging, ranging from x-ray to neutron scattering, would empower our understanding to counteract loss challenges in the electrocatalysis systems. In this project we aim the following goals:

- Utilize different modification methods to reduce bubble formation on the catalyst surface and comparing them with each other
- Using different materials for electrode preparation to improve electrocatalyst activity
- Applying advanced imaging method to in-situ and mortem analysis of electrode surface
- To understand and optimize mass transport through the water electrolysis system

References:

1- Deng, Chen, et al. "Earth-Abundant Metal-Based Electrocatalysts Promoted Anodic Reaction in Hybrid Water Electrolysis for Efficient Hydrogen Production: Recent Progress and Perspectives." Advanced Energy Materials (2022): 2201047.

2- Bae, Misol, et al. "Superaerophobic Polyethyleneimine Hydrogels for Improving Electrochemical Hydrogen Production by Promoting Bubble Detachment." Advanced Energy Materials (2022): 2201452.

3- Gatard, Vivien, et al. "Durability of the $FeNi_3$@ Ni Material Designed for Water Electrolysis Enhanced by High Frequency Alternating Magnetic Field." ACS Applied Energy Materials (2022).