PhD Thesis "Systematic study of factors influencing electrode reaction kinetics in steam electrolyzers"

Context:
Hydrogen production *via* high temperature electrolysis is a promising technology but it still requires further development to meet market needs. The constituents of electrolysis cells need to be improved with respect to their performance and stability, in order to drive the cost of the systems down. In particular, gas reactions at the electrodes are associated with potential drops (over potentials) that limit the efficiency of the cells. A better understanding of gas reactions at the electrodes could help in defining new strategies to limit those over potentials. **This PhD proposal aims to study redox potentials of transition metals in oxides used as air and fuel electrodes in steam electrolyzers.**

Objectives:
The main idea that motivates this project is that reactions at the electrodes of an electrolyzer involve a charge transfer step, which is greatly influenced by the equilibrium between various oxidation states of the transition metal in the oxide. The first task of this project will study spinel type phases whith respect to their redox and catalytic properties toward the oxygen exchange reaction (air electrode). Owing to the two different cation sites in the spinel structure, it can accommodate a wide range of compositions and oxidation states for transitions metals, which make it ideal for studying the relationship between cation redox potential and catalytic activity toward oxygen exchange reaction. To isolate the redox properties from other factors influencing the reaction kinetics (*i.e.* ionic and electronic transport properties), the spinels will be prepared “in situ” on a host material that can buffer the transport properties, which will facilitate the study of redox properties. The second task aims to study metallic alloys as catalysts for water reduction at the fuel electrode. The design of the alloys will be done so that one metal is active toward the reaction, and the second metal will only influence the redox properties of the first *via* an inductive effect.

Research environment and resources :
The PhD project will be done at the Institut des Matériaux Jean Rouxel in Nantes. The student will join the Electrochemical Energy Conversion and Storage team. The team has an extensive expertise studying ceramic materials for solid oxide fuel cells and electrolyzers. The electrocatalytic properties of the materials will be characterized by two newly set techniques available in the lab based on conductivity relaxation measurements. Those techniques will be adapted during the course of the project to study other reactions (H_2O reduction, CO_2 reduction, H_2 oxidation, etc.). They will also be coupled with mass spectrometry to investigate the evolution of gas composition during those reactions. A collaboration with Professor Tuller at the Massachusetts Institute of Technology (MIT) can also be considered for additional experiments regarding transport properties of the catalysts materials.

Candidate profile :
The ideal candidate must have a strong scientific interest in fundamental studies and a desire to develop expertise in solid state chemistry and electrocatalysis. Graduate from a master degree program or equivalent, the candidate should have training in ceramic materials synthesis (solid state reaction, Pechini, soft chemistry), characterizations (chemical analysis, X-ray diffraction, spectroscopy and microscopy), and electrochemical characterizations (electrical conductivity measurements, impedance spectroscopy). He/She will take part in research activities of the team and will have the opportunity to present their work in national and international conferences.

Funding : ANR Jeune chercheur BATELCAT (3 ans)
Starting date : October, 1st 2021
Salary: 1400 € / month

Advisor: Dr. Clement Nicollet (CNRS)
Co-advisor: Prof. Olivier Joubert (Université de Nantes)
How to apply: The candidates are encouraged send their application to Dr Nicollet (clement.nicollet@cnrs-imn.fr) including a detailed CV, Master program transcript, cover letter, and other documents that should be considered in the support of their candidacy (*e.g.* letter of recommendation, thesis paper, etc.).