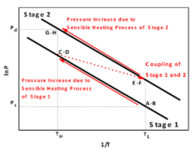
Laboratory of Materials for Renewable Energy (LMER)
Institute of Chemical Sciences and Engineering (ISIC)
Basic Science Faculty (SB)
École polytechnique fédérale de Lausanne (EPFL) Valais/Wallis

MASTER THESIS TOPICS

Please send your application including your CV to ivana.suter@epfl.ch

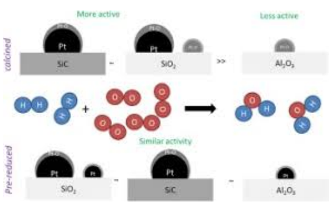
Hydrogen sorption on nano materials

The hydrogen sorption on nano porous materials is temperature and pressure dependent. Due to the large specific surface area of these materials the hydrogen storage capacity is potentially very large. The Van der Waals interaction requires low temperatures, therefore, the investigation of the thermodynamics of the hydrogen sorption requires sophisticated experiments under extreme conditions. The objective is the experimental investigation and the modelling of the hydrogen adsorption on nanomaterials as a function of temperature.



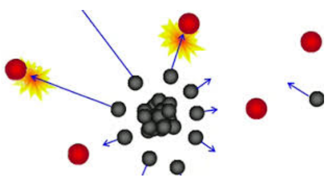
Metal hydride compression

The equilibrium gas pressure over a metal hydride is a function of the temperature (Van't Hoff relation). Therefore, a metal hydride is used to compress hydrogen by thermal energy. The transfer of heat and the requirement to hold a high pressure are working against each other. The objective is to develop a thermal model for the MH-system.



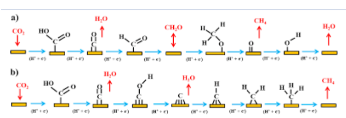
Catalytic hydrogen combustion (thermography)

The catalytic combustion of hydrogen produces directly heat at potentially high temperatures. Due to the wide concentration range of the explosion limit of hydrogen in air the combustion has to be carefully controlled in order to achieve a high power density. The hydrogen concentration, the temperature, the gas flow and the catalyst distribution are the parameters that define the power output of the hydrogen combustion. The objective is to create and describe a catalytic combustion device.



Chemical reactions by plasma activation

Catalysts are essential for the CO_2 reduction reaction since the reaction equilibrium shifts to the reactants (CO_2 and H_2) with increasing temperature. However, the catalyzed reaction is always a compromise between the kinetics and the thermodynamic limit (yield). The main purpose of the catalyst is to bind CO_2 and H_2 in order to dissociate the bonds more easily. The plasma at the entrance of the reactor allows to dissociate all the incoming molecules and the atoms, radicals and ions react subsequently in the isothermal reactor. The objective is to investigate the conditions for the product distribution.



Synthesis of catalysts for the CO2 reduction reaction

Catalysts are essential for the CO_2 reduction reaction since the reaction equilibrium shifts to the reactive (CO_2 and H_2) with increasing temperature. Catalysts are often deposited on a substrate as small (nanosized) metal particles. Several processes are known to deposit metal particles, e.g. wet chemical reduction reaction, cluster deposition. The goal of the project is a method that allows to deposit metal clusters with a controlled density and controlled size on

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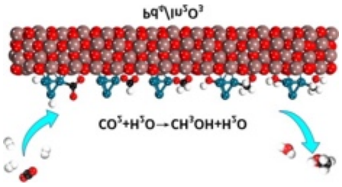
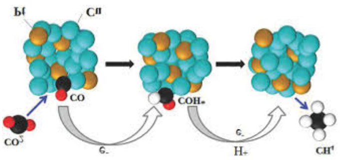
a substrate like Al_2O_3. Furthermore, the catalytic activity of the catalysts is investigated by mass spectroscopy and thermography.



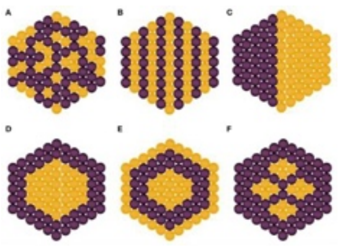
Reactivity of Au/In_2O_3 model catalyst for CO_2 hydrogenation

In_2O_3-based catalysts are very selective for CO_2 hydrogenation to methanol. Gold nanoparticles (Au NPs) have great potential to further improve the activity of In_2O_3. In this project, the student will prepare Au/In_2O_3 model catalyst by size-selective nanoparticle deposition and investigate the reactivity of CO_2 and H_2 using near-ambient pressure X-ray photoelectron spectroscopy (NAP-XPS). The student will learn the fundamentals of catalysis, as well as advanced surface science techniques.



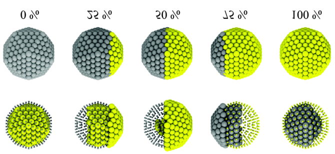
Surface atomic population of Cu-In bimetallic catalysts during CO_2 hydrogenation reactions

Cu-In bimetallic catalysts have great activity and selectivity in both thermocatalytic and electrocatalytic CO_2 hydrogenation reactions. To further improve the performance of the catalysts, it is important to investigate their surface composition under reactive atmosphere. In this project, the student will monitor the change of active sites of Cu-In bimetallic catalysts during CO_2 hydrogenation reactions using near-ambient pressure X-ray photoelectron spectroscopy (NAP-XPS). The student will learn the fundamentals of catalysis, as well as advanced surface science techniques.



Development of a Cu-based bimetallic nanoparticle library for the CO2RR

The electrochemical conversion of CO2 into fuels and chemicals is a promising route to close the carbon cycle. Unfortunately, activity issues with tried catalysts prevent this reaction from becoming technology. With systematic screening of catalyst libraries, structure-activity relationships can be proposed, which help locate the optimal candidate. The goal of this project is to develop such a library based on a lead candidate CuX with promising properties using various wet-chemistry techniques. Advanced characterization using XPS and TEM will be carried out. If time allows it, electrochemical testing will be sought out.



Characterization of state-of-the-art Cu-based substrates for in-situ observation of surface intermediates in the CO2RR

The electrochemical conversion of CO_2 into fuels and chemicals on Cu is mechanistically poorly understood. To develop better catalysts, mechanistic insight is of utmost importance. Raman scattering based spectroscopic techniques are showing promising results to this effect but have been limited to very specific substrates. In this project, newly developed Cu substrates that are both active in the CO2RR and have strong Raman enhancement factors will be produced and characterized using various experimental techniques such as SEM, UV-vis and FTIR. In-situ electrocatalysis will be performed if time allows it.