Ecole Doctorale - 104

Sciences de la Matière, du Rayonnement et de l'Environnement

EDSMRE

UNIVERSITY: Lille University/ Osaka University

Scientific field : Heterogeneous catalysis, nanoparticles, X-ray spectroscopy, microscopy

Title of the thesis: Design and Mechanistic Study of High-Entropy Intermetallic Catalysts

Supervisor: Dr. Héloise Tissot (Lille University), Prof. Shinya Furukawa (Osaka University)

Laboratory: Unité de Catalyse et Chimie du Solide (UCCS, UMR-CNRS 8181), Furukawa Lab (Osaka University
https://www-chem.eng.osaka-u.ac.jp/furukawa/index_en.htm
https://uccs.univ-lille.fr/axes-de-recherche/catalyse-heterogene/modspec

Related research project (international/national/regional): Chaires WILL, HEI! Project

Project Description:

This PhD project is based on a collaboration between Professor Furukawa's group at Osaka University, a pioneer in catalysis and high-entropy intermetallics (HEIs), and the MODSPEC team at UCCS/University of Lille, Dr. H. Tissot, within the framework of the WILL Chairs program.

The project aims to explore HEIs as catalysts for sustainable chemical reactions, with a primary focus on the oxidative dehydrogenation of propane using CO_2 as an oxidant to produce CO and H_2O. However, other reactions may also be investigated. HEIs combine the properties of multiple metals with an ordered atomic structure, offering enhanced stability, adaptability, and catalytic efficiency compared to disordered high-entropy alloys (HEAs). The goal is to design efficient HEI catalysts and understand their stability and reactivity in catalytic processes.

Advanced characterization techniques, including X-ray photoelectron spectroscopy (XPS), near-ambient pressure XPS (NAP-XPS), infrared (IR), X-ray diffraction (XRD), and transmission electron microscopy (TEM), will be employed. Special emphasis will be placed on operando techniques, particularly NAP-XPS, to probe the dynamic surface composition of HEIs under reaction conditions. The NAP-XPS setup at Lille's Institut Chevreul (UCCS) will allow for in-depth analysis of catalytic processes, helping to identify active sites, monitor reaction intermediates, and elucidate catalytic mechanisms in real time.

This research will contribute to improving the design and efficiency of HEIs for industrial applications, particularly in CO_2 conversion and propylene production, while minimizing catalyst deactivation.

PhD Objectives and Expected Outcomes

The PhD research aims to:

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- Develop high-performance HEI catalysts for reactions such as propane ODP using CO_2.
- Investigate phase stability and surface reactivity of HEI nanoparticles.
- Identify active sites and reaction intermediates using in situ/operando techniques, with a particular focus on NAP-XPS studies at UCCS.
- Optimize catalyst design to enhance production while minimizing deactivation mechanisms.

The selected candidate will gain expertise in catalyst synthesis, advanced surface characterization, and operando spectroscopy techniques. He will have the opportunity to spend up to one year at Osaka University as part of the WILL Chair program, creating international collaboration and knowledge exchange.

Candidate Profile

We are looking for a highly motivated candidate with:

- A Master's degree (or equivalent) in chemistry, materials science, or a related field.
- Background in catalysis, surface science, or spectroscopy techniques.
- Strong analytical skills and ability to work in an interdisciplinary environment.
- Willingness to conduct research stays in Lille and Osaka.

Application Process: Interested candidates should submit their CV, cover letter, and academic transcripts to Dr. H. Tissot (University of Lille) heloise.tissot@univ-lille.fr. Applications will be reviewed on a rolling basis until the position is filled.

Planned recruitment date: October 2025

Profile: Master in Material Science, Physical Chemistry or Inorganic Chemistry with knowledge in Spectroscopy and/or material synthesis.

Additional remarks/comments :

The position for which you are applying is likely to be located in a "restricted area" within the meaning of article R. 413-5-1 of the penal code. If this is the case, your appointment and/or assignment can only take place after access authorization has been issued by the head of the institution, in accordance with the provisions of article 20-4 of decree n°84-431 of June 6, 1984.