MASTER DE CHIMIE DE PARIS CENTRE - M2S4
Proposition de stage 2024-2025
Internship Proposal 2024-2025

Parcours type(s) / *Specialty(ies) :*

☑ Chimie Analytique, Physique et Théorique */ Analytical, Physical and Theoretical Chemistry*
☐ Chimie Moléculaire / *Molecular Chemistry*
☐ Chimie et Sciences Du Vivant / *Chemistry and Life Sciences*
☑ Chimie des Matériaux / *Materials Chemistry*
☑ Ingénierie Chimique / *Chemical Engineering*

Laboratoire d'accueil / *Host Institution*

Intitulés / *Name* : Laboratoire de Réactivité de Surface (UMR 7197)
Adresse / *Address* : 4 place Jussieu 75005 Paris
Directeur / *Director (legal representative)* : VIVIER Vincent
Tél / *Tel* : 01 44 27 25 77
E-mail : vincent.vivier@sorbonne-universite.fr

Equipe d'accueil / *Hosting Team :*

Adresse / *Address :*
Responsable équipe / *Team leader* : WILSON Axel
Site Web / *Web site :*
Responsable du stage (encadrant) / *Direct Supervisor :* WILSON Axel
Fonction / *Position :* Chargé de Recherche CNRS
Tél / *Tel* : 01 44 27 30 50
E-mail : axel.wilson@sorbonne-universite.fr

Période de stage / *Internship period* * : 03/02/2023 – 27/06/2025

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* **min. 5 mois, maximum 6 mois à partir du 27 janv 2025 / *min. 5 months and max. 6 months not earlier than January, 27th 2025.***
Fin des conventions de stage au plus tard le 15/07/2025 ou le 15/09/2025 et le 15 novembre 2025.
End of internship at the latest July 52, 2025 or September. 15, 2025 and 15 November, 2025.

Design of a Microfluidic Reactor for the Synthesis of Nanoscale High Entropy Alloys

Background & Challenges: High Entropy Alloys (HEAs) are a unique class of metal alloys composed of five or more elements in nearly equimolar ratios. These alloys exhibit remarkable properties across various domains. Recently, attention has shifted towards nanoscale HEAs (nano-HEAs), which show promising structural and chemical properties for catalytic applications [1, 2]. However, the synthesis of nano-HEAs is challenging and demands advanced characterization techniques to accurately measure their composition and configuration.

Objectives: A research team led by Dr. Axel Wilson at the LRS has initiated a pioneering project aimed at leveraging recent advances in the catalytic properties of nano-HEAs. This internship will involve the following key objectives:

1. Development of a Continuous Flow Synthesis Method: Design and optimize a microfluidic reactor for the continuous production of nano-HEAs.
2. Characterization of Nano-HEAs: Employ multiple experimental techniques to analyse the chemical composition, configuration, morphology, and structure of the synthesized nano-HEAs.
3. Evaluation of Catalytic Performance: Test the catalytic performance of nano-HEAs using a model reaction, specifically the methanation of CO_2, a key process in Power-to-Gas technology.

Technical Details: The continuous flow synthesis will be carried out using micro-reactors, which are microfluidic devices that mix reactants at high temperatures in a controlled flow. This method offers several advantages over traditional batch reactors, including scalability, larger surface-to-volume ratios, and enhanced heat transfer. The continuous flow setup also ensures reproducible production by maintaining precise control over synthetic conditions and minimizing operator influence.

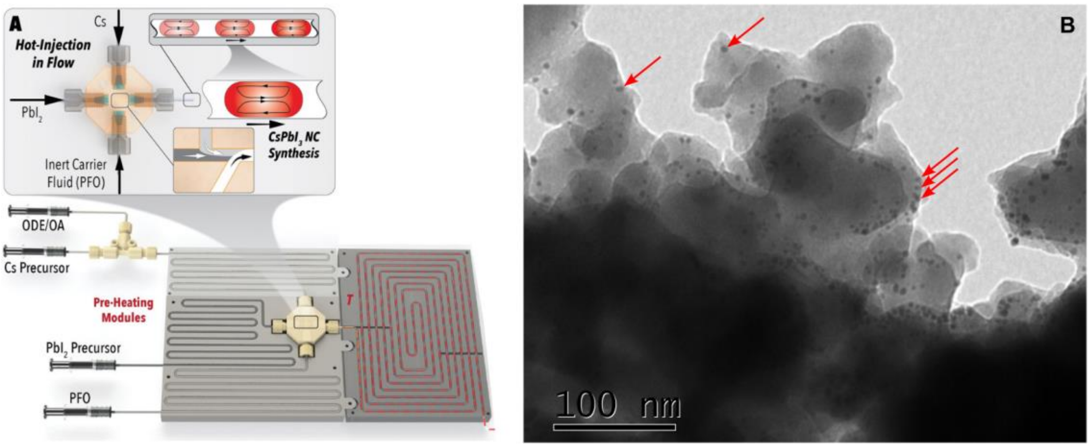

Figure 1. A: microfluidic flow reactor designed for the synthesis of $CsPbI_3$ nano-crystals (from [3]). B: 4 nm Co-Fe-Pt-Ni-Ru nano-HEAs synthesised at LRS in July 2024 deposited onto a silica powder. The arrows are pointing towards the nanoparticles which catalytic properties will be tested during the internship.

The synthesized nano-HEAs will be characterized to establish correlations between their properties and catalytic performance, with the ultimate goal of optimizing these catalysts for improved activity and stability. This will be carried out using transmission electron microscopy (TEM) and X-ray diffraction (XRD). In the context of heterogeneous solid/gas catalysis, the candidate will focus on the catalytic methanation of CO_2, a reaction that converts CO_2 and H_2 into methane. This reaction is central to Power-to-Gas technology, which facilitates long-term storage solutions for hydrogen [4].

Candidate Profile: We seek a motivated candidate with a strong interest in laboratory experiments, specifically in the development and optimization of bench-top microfluidic reactors. The candidate will collaborate with a team conducting TEM, XRD measurements, and catalytic tests using a new micro-gas chromatograph. Additionally, training will be provided in rapid prototyping, including the design and 3D printing of functional parts. For applications, please contact Dr. Axel Wilson (axel.wilson@sorbonne-universite.fr). If you encounter any issues accessing the references below, feel free to reach out.

[1] Xie P. et al., *Nat. Commun.* **2019**, 10, 4011 (https://doi.org/10.1038/s41578-019-0121-4)
[2] Nellaiappan S. et al., *ACS Catal.* **2020**, 10, 3658−3663 (https://doi.org/10.1021/acscatal.9b04302)
[3] Antami, K et al., *Adv. Funct. Mater.* **2022**, *32* (6), 2108687 (https://doi.org/10.1002/adfm.202108687)
[4] Obeid M. et al., *Chem. Eng. J.*, **2023**, 474, 145460, (https://doi.org/10.1016/j.cej.2023.145460)