

PhD candidate position in materials chemistry

Hydroflux synthesis of oxides containing unusual high-oxidation metals

Hydroflux – Nanomaterials – Shape control – Synthesis – Electrocatalysis – Energy conversion

Location: [Laboratoire Chimie de la Matière Condensée de Paris](#), Sorbonne Université, Jussieu

Starting date: October 2026

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Context

The development of materials is mandatory to tackle societal challenges. Tuning materials properties requires precise adjustment of the crystal structure and particle morphology. However, this control cannot be achieved for all materials. **High-valence metal oxides** are a good example of this limitation. The activity of many electrochemical oxygen-evolving pre-catalysts used in water splitting for H₂ production is credited to high-valence metals formed *in situ* under potential bias.¹ Solids containing metals in these **unconventional oxidation states**, e.g. Mn^{+V}, Ni^{+IV} and Fe^{+IV}, are barely reported and require harsh solid-state synthesis conditions.^{2,3} These features hinder grain size and morphology control, which are relevant for **catalytic applications**. We have shown recently that Mn^V oxides can be synthesized with shape and size control in **original, green and underexplored solvents**, so-called **hydrofluxes**.⁴ These media are mixtures of alkali metal hydroxide(s) and water in close-to-equimolar proportions.⁵ Their main development has occurred in the last decade, and since then tens of new crystalline phases were discovered. Despite that, most studies were driven by curiosity about their crystallography, and did not address any property. In addition, the chemistry at stake in these media remains largely unexplored.

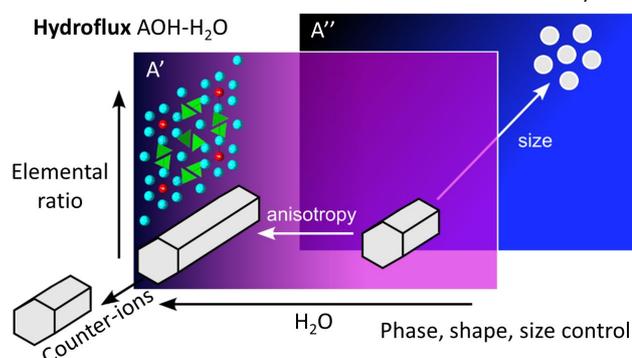
Objectives

We are the only group that has ever reported independent size and shape control into hydrofluxes.⁴ We want now to generalize this control to other (nano-)objects based on high-valence metal oxides. These materials will be applied as catalysts for electrochemical **oxygen evolution reaction**, as pre-existing high-valence metals are expected to increase electrocatalytic activity. The interest of nano-sized objects relies on the increasing active sites density, while shape diversity allows correlating reaction kinetics with crystal facets. Although this correlation is usual in traditional catalysis community,⁶ it was never addressed for complex solids due to the inability to control their **crystal shape and size**. A multiparametric approach will be applied to target **original materials**, and correlate structures and morphologies to the physical chemistry of hydrofluxes. The project comprises **nanomaterials synthesis and characterization**, and **electrocatalysis** applied to **energy conversion**.

References in green are from the host team:

[1] Bediako, et al. *J. Am. Chem. Soc.* **2012**, 134, 6801. [2]

Alonso et al. *Funct. Mater. Lett.* **2011**, 4, 333. [3] Tan et al. *Inorg. Chem.* **2018**, 57, 10410. [4] Inocencio, et al. *Inorg. Chem.* **2025**, 64, 5122. [5] He, et al. *Z. fur Anorg. Allg. Chem.* **2023**, 649, e202300170. [6] Xue, et al. *ACS Catal.* **2021**, 11, 8239.



Laboratory and team

At [LCMCP](#) we are developing basic and applied research in materials science addressing urgent societal challenges, from energy crisis to medicine. We are searching to understand how materials form in Nature, how to design new materials, how to process them and how to target specific functions. Our lab is affiliated to CNRS and Sorbonne Université, two prestigious French institutions. It is located in the center of Paris on the campus of Sorbonne Université. You will work in the Novel Advanced Nano-Objects ([NANO](#)) team gathering chemists and materials scientists, who are joining to perform cutting edge research in nanochemistry.

Required skills

- Knowledge in materials science (synthesis, characterizations, and properties).
- Interest in electrocatalysis.
- Appeal for collaborative work, and scientific reading, discussion and writing.