# Post-doctoral position

## "Metal-Containing Nanoparticles for the Catalytic Activation of Small Molecules"

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*Keywords:* Surface reactivity, Nanoparticles, Catalysis, Organic-inorganic interface, $CO_2$ conversion.

**Duration:** 24 months from May 2023 (initial contract of 12 months, extendable for 12 more months)
**Funding:** ERC Project *NanoFLP* (https://sophiecarenco.cnrs.fr/index.php?side=project5)
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**About the team.** The team Nano is hosted by *Sorbonne University* and *CNRS*. It is internationally recognized for the **design and applications of nanomaterials**. Metal oxides nanomaterials, and more recently metal-alloys nanomaterials that contain lighter elements (eg. phosphorus, carbon, sulfur)[1-3] are prepared and studied both in academic and industrial projects for their applications in several fields: optical materials, automobile and aeronautics, energy harvesting and storage, industrial catalysis, nanomedicine.

**Our lab is fully equipped** for the project: Schlenk-lines, glovebox, autoclaves, transmission electron microscope, X-ray diffraction, X-ray fluorescence spectroscopy and NMR are available within our walls.

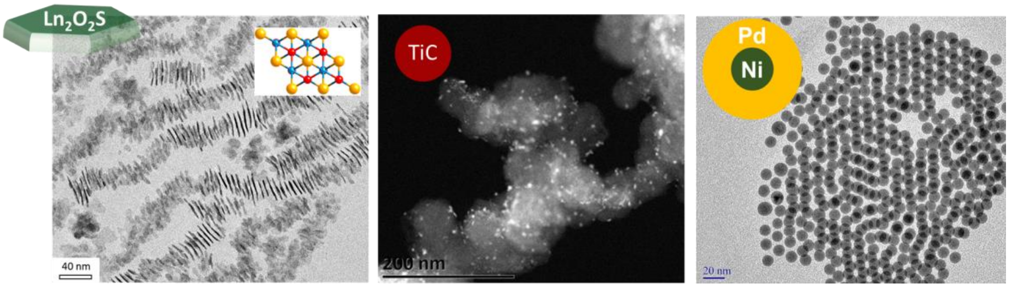


**Figure 1: Examples of nanoparticles routinely prepared in the team**

**Context of the project.** Catalysis with nanoparticles is a field older than the word "nanoparticle" itself: since the 19th century, chemists were employing highly divided metal nanoparticles to activate $H_2$ (eg. with platinum) and use it as a reducing agent in the methane production from $CO_2$ (Sabatier reaction, catalyzed with nickel). However, as processes developed at an industrial scale (eg. Fischer-Tropsch process, Haber-Bosch process), **the general trend was to move to stronger and stronger catalytic conditions** (such as a few hundred bars and a few hundred degrees) in order to avoid the use of noble metals. This prevented the formation of more fragile molecules such as alcohols or amines in these processes.

**There is an unmet need for lower-temperature processes, catalyzed by metals neither rare nor precious**, in order to form products as interesting as these provided by homogeneous catalysis. In this purpose, the surface chemistry of nanoparticles has to be revisited and "boosted", such as it will activate H-H, C=O, N=O and S=O bonds under mild conditions (eventually, less than 3 bars and less than 150 °C). By analogy with strategies developed in molecular chemistry, we use **ligand-metal interaction at the surface of well-defined nanoparticles** to develop a new concept in catalysis and apply it to the activation of small molecules such as $CO_2$ and $H_2$. **We have now published the proof of concept for this strategy, using NiCo nanoparticles, and we want to move forward with other nanoparticles and reactivity with gases.**[5]

The ERC project *NanoFLP*, that encompasses nanoparticles synthesis, *in situ* monitoring and spectroscopy, is now in its last phase where we will take full opportunity of the already developed colloidal nanoparticles for investigations in reactivity and catalysis with molecules such as $CO_2$, $H_2$ and $SO_2$, using solution NMR as a key tool to monitor the reactions performed in small autoclaves.

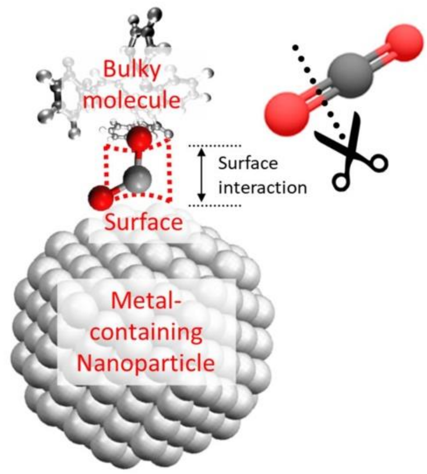


**Figure 2: Tailored surface interaction for achieving low-temperature and low-pressure catalytic reactions**

**Description of the post-doctoral fellow project missions.** The post-doctoral fellow will bring to the team an expertise in catalysis related nanochemistry, coming from either the homogeneous catalysis or the heterogeneous catalysis. He/she will perform catalysis investigation in small-scale autoclaves, monitor their outcome and investigate the reaction mechanisms when possible. He/she will also prepare the nanoparticles used as catalysts and characterize them with standard materials science techniques (such as XRD and TEM).

**Candidate Profile.** The candidate should have a strong background in molecular chemistry and catalysis (homogeneous or heterogeneous) using nanoparticles or organometallic complexes. He/she should have a background in inorganic chemistry or materials science (for example: nanoparticles synthesis, characterization techniques such as XRD or TEM). He/she should be already fully trained with Schlenk-line techniques and solution NMR. He/she should have experience in writing articles from his/her work.

**Application.** CV with publication list (mentioning the nature and extent of your contributions in the most relevant papers), as well as a short cover letter including what you can bring to the project and what you hope to learn from it. Please specify the names of your previous advisors (as a PhD student and/or in a previous post-doctoral stay) in your CV.

**References:**

[1] S. Carenco, Designing Nanoparticles and Nanoalloys with Controlled Surface and Reactivity. *Chem. Rec.* **2018**, *18* (7–8), 1114–1124.
[2] S. Carenco, Describing inorganic nanoparticles in the context of surface reactivity and catalysis. *Chem. Commun.* **2018**, *54 (50)*, 6719–6727.
[3] X. Frogneux, F. Borondics, S. Lefrançois, F. D'Accriscio, C. Sanchez, S. Carenco. Surprisingly high sensitivity of copper nanoparticles toward coordinating ligands: consequences for the hydride reduction of benzaldehyde. *Catal. Sci. Technol.* **2018**, *8 (19)*, 5073–5080.
[4] S. Carenco, C.-H. Wu, A. Shavorskiy, S. Alayoglu, G. A. Somorjai, H. Bluhm, M. Salmeron. Synthesis and Structural Evolution of Nickel-Cobalt Nanoparticles Under $H_2$ and $CO_2$. Small **2015**, *11 (25)*, 3045–3053.
[5] A. Palazzolo, S. Carenco. Phosphines Modulating the Catalytic Silane Activation on Nickel–Cobalt Nanoparticles, Tentatively Attributed to Frustrated Lewis Pairs in a Colloidal Solution. Chem. Mater. **2021**, *33 (19)*, 7914–7922.