AUFRANDE

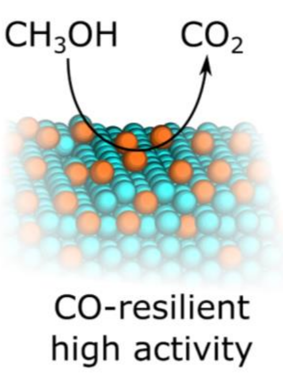
Position Description

1. General Information

Name of the position	**Nanoparticle based catalysis**
Foreseen date of enrolment	1 July 2024
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • Institut National des Sciences Appliquées, Toulouse • University of New South Wales
Research Host	Institut National des Sciences Appliquées, Toulouse
PhD awarding institutions	Institut National des Sciences Appliquées (INSA-T) & University of New South Wales (UNSW)
Locations	Primary: Toulouse, France Secondary: Sydney, Australia
Supervisors	Lise-Marie LACROIX (INSA-T) and Richard David Tilley (UNSW)
Group of discipline	Chemistry, Material science

2. Research topics (only one of these projects will be funded)

Project 1: *Synthesising Single Atom Pt catalysts on metal nanoparticles for enhanced electrocatalytic activity in methanol fuel cells*



Methanol fuel cells are important for devices that require high energy. Platinum-ruthenium is the most active methanol oxidation catalysts which can convert methanol to carbon dioxide. However, the Pt atoms on the catalysts can easily become poisoned by CO which forms during the conversion of methanol. Depositing Pt directly onto Ru nanoparticles creates single atom Pt. These single atom Pt sites are unique in their catalytic properties being highly active and do not become poisoned by CO (Figure).[1]

In this project, nanoparticles will be decorated with single Pt atoms for use as high performance catalysts. By controlling the position of Pt atoms on different metal nanoparticle structures, both electrocatalytic activity and stability will be optimised to create the most advanced and effective nanoparticle catalysts. This project will use the latest aberration corrected transmission electron microscope to characterize the catalysts.

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement Nº 101081465

1. Poerwoprajitno, A.P ….Tilley, R.D. et al. A single-Pt-atom-on-Ru-nanoparticle electrocatalyst for CO-resilient methanol oxidation. Nature Catalysis. 5, 231-237 (2022).

Supervisors: Prof. Lise-Marie Lacroix (INSA-T), Prof. Richard David Tilley (UNSW), Prof. Edwin A. Baquero (UNAL)

Non-academic advisor: Dr. Jean-Christophe Cau (IKI)

Research Fields: Nanoparticle synthesis, Electrocatalysis

Project 2: *Controlling nanoparticle structure for active and stable catalysts in renewable energy storage*

The oxygen evolution reaction (OER) is crucial for the storage and conversion of H2 fuel and requires highly active and highly stable catalysts to drive it. Our expertise in nanoparticle synthesis has allowed us to create the most active and stable nanocatalysts for OER reported to date.1 We achieved this by synthesizing 3D branched Ru nanoparticles with structural features that both prevent dissolution and improve oxidation catalysis (Figure 1).

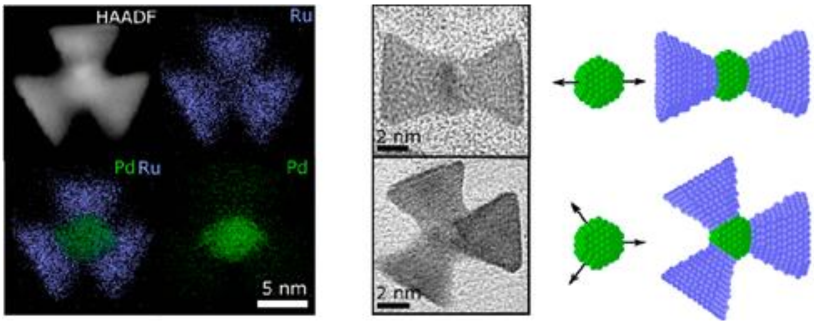


Figure 1: Energy dispersive X-ray spectroscopy elemental mapping of Pd-Ru branched nanoparticles and TEM images of individual nanoparticles. Models show the controlled direction of growth of Ru from Pd seed.

In this project, Ru nanoparticles will be synthesized with low index facets which are critical for achieving stable reaction kinetics that prevent dissolution of Ru and enhance the catalytic activity. This work will combine the development of synthetic methods to control the size, shape and composition of Ru-based nanocatalysts, with advanced characterisation using high-resolution transmission electron microscope and also evaluation of their electrocatalytic performance. This allows for the relationships between nanoparticle structure and catalytic performance to be fundamentally understood and tuned to create leading nanocatalyst materials.

1. Gloag, L….Lacroix, L-M….Tilley, R.D. et al. Three-Dimensional Branched and Faceted Gold–Ruthenium Nanoparticles: Using Nanostructure to Improve Stability in Oxygen Evolution Electrocatalysis. Angewandte Chemie 57, 10241 (2018).

Supervisors: Prof. Lise-Marie Lacroix (INSA-T), Prof. Richard David Tilley (UNSW), Prof. Edwin A. Baquero (UNAL)

Non-academic advisor: Dr. Jean-Christophe Cau (IKI)

Research Fields: Nanoparticle synthesis, Electrocatalysis

Project 3: *Synthesising strained Pt on metal nanoparticles for enhanced electrocatalytic activity in hydrogen fuel cells*

In order to convert to sustainable energy cells in a hydrogen economy, nanocatalysts need to be high-performing and use minimal amounts of scarce Pt. Strained Pt on the surface of a metal nanoparticle is a promising structure for highly active fuel cell catalysts. Depositing Pt directly onto Ni nanoparticles creates highly strained Pt that maximises the specific and minimises the amount of expensive Pt that is used to provide the highest mass activities reported to date (Figure 1).[1]

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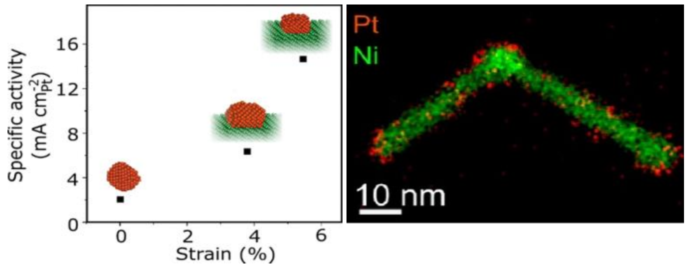
In this project, nanoparticles will be decorated with small clusters of Pt atoms for use as high performance catalysts. By controlling the position of Pt atoms on different metal nanoparticle structures, both electrocatalytic activity and stability will be optimised to create the most advanced and effective nanoparticle catalysts.

Figure 1: Relationship between strain and HER activity and elemental map of a Pt on Ni nanoparticle.[2]



1. Alinezhad, A. et al. Direct Growth of Highly Strained Pt Islands on Branched Ni Nanoparticles for Improved Hydrogen Evolution Reaction Activity. J. Am. Chem. Soc. 141, 16202–16207 (2019).

Supervisors: Prof. Lise-Marie Lacroix (INSA-T), Prof. Richard David Tilley (UNSW), Prof. Edwin A. Baquero (UNAL)

Non-academic advisor: Dr. Jean-Christophe Cau (IKI)

Research Fields: Nanoparticle synthesis, Electrocatalysis

3. Employment Benefits and Conditions

Institut National des Sciences Appliquées, Toulouse offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). The total working hour per week is 37.5h.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of EUR 28,320. Of this amount, the estimated net salary to be perceived by the Researcher is EUR 1,895 per month. However, the definite amount to be received by the Researcher is subject to national tax legislation.

Benefits include

- Becoming a Marie Skłodowska-Curie fellow and be invited to join the Marie Curie Alumni Association
- Access to all the necessary facilities and laboratories at INSA-T and UNSW, including LPCNO's facilities and laboratories, as long as common platforms for advanced microscopy and NMR spectroscopy
- Tuition fees exemption at both PhD awarding institutions
- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events
- 10,000 EUR allowance to cover flights and living expenses for up to 12 months in Australia
- 51 days paid holiday leave
- French Social security coverage
- Sick leave
- Parental leave

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4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRANDE's conditions.

Applicants must hold a Master of Science degree in chemistry, physics, physical chemistry or nanosciences with excellent grades, a substantial research component and demonstrated capacity for timely completion of a high-quality research thesis.
Applicants must demonstrate an English language proficiency equivalent to an overall IELTS score above 6.5 and no band below 6. Note that the test needs to be completed no more than two years before enrolment. The English language test scores requirements can be found here: https://www.unsw.edu.au/study/how-to-apply/english-language-requirements.

More information on INSA-T's requirements

Visit the websites: https://www.insa-toulouse.fr/sinscrire-et-se-reinscrire-en-doctorat/ & https://ed-sdm.univ-toulouse.fr/as/ed/page.pl?page=puinscription&site=edsdm

More information on UNSW's requirements

Applicants will be required to submit an application on UNSW website in parallel.

Visit the website: https://research.unsw.edu.au/higher-degree-research-programs

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