PhD thesis offer (36 months contract) - M/F

## Carbon-based ionic electrodes for the electro-enzymatic conversion of $CO_2$ to formate

*Applications possible until 30 June 2023 (contacts below)*

Formate dehydrogenases (FoDHs) are able to selectively reduce $CO_2$ into formate. To do so, FoDHs require the loosely bound cofactor nicotinamide adenine dinucleotide (NAD) in its active reduced form, 1,4-NADH. We already demonstrated the ability of FoDHs to work in a tandem reaction together with a phosphite dehydrogenase mutant from *Pseudomonas stutzeri* (PtDH), in charge of the clean *in situ* regeneration of 1,4-NADH. Recently, we used the FoDH from *Methylobacterium extorquens* AM1 (*Me*FoDH1), which demonstrates superior $CO_2$ reducing properties and excellent stability under aerobic conditions [*Green Chem. 22*, **2020**, 3727]. However, NAD is relatively expensive and unstable in the presence of $CO_2$, making this bi-enzymatic setup unstable over time.

In this project, an elegant alternative to NAD would be to promote the direct electron transfer (DET) between *Me*FoDH1 and the surface of an electrode. The molecular functionalization of innovative nanocarbon electrodes will be performed in order to promote the electrical wiring *via* DET. In particular, original ionic liquids [*J. Colloid. Interface Sci. 636*, **2023**, 668] and nanocarbon-based hybrid ionogels [*Nanoscale 13*, **2021**, 2750] will be developed and employed as supports for *Me*FoDH1.

The work will be carried out in the brand new Balard building (CNRS site) in Montpellier, within the framework of the ANR project $CO_2$FFEE. The trainee will be surrounded by a dynamic and multidisciplinary **team of 5-10 people** working on enzymatic catalysis, electrocatalysis, ionic liquids and materials science in the D3-MPH department (Porous & Hybrid Materials). The study will be conducted in close collaboration with the team of Dr Damien Voiry (IEMM, Montpellier, France) and Dr Keisei Sowa (Kyoto University, Japan).

*The PhD student will be responsible for:*

**Synthesis** and **characterization** (FTIR, liquid NMR) of original ionic liquids

**Monitoring** of **catalytic reactions** with free and immobilized enzymes using HPLC and/or UV-vis spectroscopy

Nanoconfinement / immobilization of enzymes into nanocarbon-based supports (e.g., buckypapers)

Assessment of bio-**electrochemical properties** using cyclic voltammetry

**Exploitation** of the data, comparison with existing literature, **drafting** of monthly reports, **presentation** of results in weekly meetings, **communication** at national and international conferences, temporary stays abroad (possible)

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| *Profile* | **Master's degree** or **Engineering school (M/F)** with a background in **chemistry** and an interest in **nanomaterials**, **biochemistry** and **electrochemistry**<br>Interdisciplinary topic: excellent **openness** and **curiosity**<br>Required qualities: **motivation**, autonomy, **rigour**, teamwork |
| *Contract duration*<br>*Fundings* | **36 months** from **September 2023** (or October the 1st, last date)<br>ANR PRC (projet $CO_2$FFEE) & Région Occitanie Circulades (projet BIOGAZOVERT)<br>**Monthly grant**: *ca.* ***1 700 €*** |
| *Host laboratory*<br>*Contacts* | ICGM - Département MPH (D3), Campus CNRS, 1919, route de Mende, Montpellier (FRANCE)<br>**Dr Nicolas Brun**, CNRS associate Researcher - nicolas.brun@enscm.fr<br>**Dr Jullien Drone**, associate Professor ENSCM – jullien.drone@enscm.fr |
| *Applications* | Only applications submitted before 30 June 2023 will be considered (see contacts above)<br>Attach a detailed **CV**, a recent letter of **recommendation** and a **cover letter** |

CHEMISTRY: MOLECULES TO MATERIALS