

Electrodeposited Hybrid Mesoporous Organosilica Films for Neuronal Biodetection and Biostimulation

UMR – Team : ICGM UMR 5253, Department of porous and hybrid materials (D3)

Thesis supervisors : Gauthier Rydzek, MCF-HDR, gauthier.rydzek@umontpellier.fr
Carole Carcel, MCF-HC, carole.carcel@enscm.fr

Thesis start date: October 1, 2026

Funding: Institutional doctoral contract

Application deadline on ADUM: March 20, 2026

Neurotransmitter dysregulations are involved in many neurological and psychiatric disorders (depression, Parkinson's disease, schizophrenia).[1] Bioelectrodes offer new perspectives for diagnosis and therapeutic evaluation through the specific detection and controlled release of neurotransmitters. In this context, mesoporous silica films prove particularly suitable due to their large specific surface area and size-dependent permselectivity, which promote selective diffusion mechanisms. [2,3]

This PhD project aims to develop hybrid organosilica mesoporous films for a new generation of highly sensitive bioelectrodes capable of monitoring and stimulating neuronal cells. An electrochemically assisted self-assembly (EASA) approach [2,4] will be used to produce films whose nanostructure and functionalization are directed using complex polyion micelles. [5] The functional mesopores will allow both the reversible encapsulation of active compounds for biostimulation and charge-dependent permselectivity for the selective detection of cationic neurotransmitters. The ionic and electronic properties of the films will be optimized by incorporating electroconductive compounds within the mesopores and/or the organosilica walls. The biocompatibility, stimulus response, and electrochemical performance of the bioelectrodes will be evaluated to establish correlations between the nanostructure, composition, and properties of the hybrid mesoporous films.

During the project, the PhD student will learn to design and synthesize organosilica precursors [6] (silylated monomers of conducting polymers) as well as block copolymers through RAFT polymerization. The student will be trained in detailed characterization of complex polyion micelles for controlled self-assembly (SAXS, DLS) and will develop advanced skills in electrochemistry, from thin film deposition (EASA) to electrochemical characterization (cyclic voltammetry, quartz crystal microbalance). The student will also master multiscale characterization techniques (SAXS, N₂ sorption, TEM, NMR, XPS, AFM, ellipsometry, etc.) to establish relationships between structure and functional properties. Finally, they will acquire an understanding of biocompatibility testing and neuromodulation mechanisms.

Collaborations within ICGM, as well as with other institutes in Montpellier and Marcoule, will allow the PhD student to benefit from a wide range of advanced analytical techniques. An international collaboration with two partners in Taiwan will complement this work by evaluating neuromodulation performance.

[1] McCutcheon, R. A., *World Psychiatry*, **2020**, 19, 15–33. [2] Walcarius, A., *The Chemical Record*, **2024**, 24, e202300194.

[3] Koklu, A., *ACS Nano*, **2021**, 15, 8130–8141. [4] Walcarius, A., *Electroanalysis*, **2007**, 19, 129–138. [5] Rydzek, G., *Chem. Mater.*, **2025**, 37, 6077–6089. [6] Carcel, C., *J. Mater. Chem. B*, **2020**, 8, 1472–1480.

Desired profile: Master's degree in Chemistry, Materials Chemistry or Chemical Engineering, very good command of English, scientific rigor and critical thinking, autonomy and ability to take initiative, curiosity, and enthusiasm for multidisciplinary and fundamental research projects.

Valued skills: Experience in organic synthesis, experience in sol-gel chemistry, familiarity with electrochemical techniques and the characterization of thin films and porous materials. Ability to work in a multidisciplinary and international environment.

Application procedure: Send your CV (with reference contact), cover letter, and Master's transcripts (if available), along with transcripts from previous years of study, combined into a single PDF file, to the supervisors. You may also include one or two reference letters or recommendations from Master's teachers/supervisors. At the same time, you must register on the ADUM platform and apply online at: <https://adum.fr/as/ed/propositionFR.p>

Application deadline on ADUM: March 20, 2026.