

Post-doctoral position (M/W) at Nantes University for development of hybrid molecular material/semiconductor for artificial photosynthesis

Host: CEISAM-UMR CNRS 6230 at Nantes University (FRANCE)

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Starting date: October 2025 for 9 months

Project description:

Artificial photosynthesis offers the prospect of producing unlimited energy in the form of chemical fuels (such as H_2 or EtOH) for the energy sector and also raw chemicals for the industry (such as CO, MeOH, carbonyl derivatives) with sunlight as sole energy source and with abundant and cheap materials such as water or carbon dioxide.¹ Photoelectrochemical cell (PEC) is composed of semiconductors whose surface is functionalized with catalysts and immersed in an electrolyte containing the reactants. This project aims to amplify light harvesting by integrating multiple photon absorbers, thereby maximizing the overall efficiency of photocatalysis. Towards this objective, two approaches will be explored. The first involves the design of multichromophoric systems that broaden the absorption cross-section through energy transfer cascades funneling excitation to a single terminal acceptor, from which charge separation initiates. We have already demonstrated the relevance of this concept in both photoelectrochemical devices,² and photocatalytic systems.³ Here, we will extend it to dye-sensitized photoelectrosynthetic cells (DSPECs) using an array of different chromophores assembled in suitable spatial arrangement and energy gradient to convey the incident photonic energy to the sensitizer of the inorganic semiconductor (NiO or TiO_2).⁴ The second approach draws inspiration from the natural “Z-scheme” of oxygenic photosynthesis, which couples two distinct light absorbers. In our design, one absorber will be a molecular dye, the other a low-bandgap inorganic semiconductor. Recently, we achieved Z-scheme operation with high quantum yield using a molecular tetrad,⁵ reminiscent of the dual photosystem architecture (PSI and PSII) found in green plants. Building on this, we propose to engineer hybrid systems in which immobilized molecular photosystems are integrated with inorganic semiconductors exhibiting strong visible absorption. The proposed concepts are at the forefront of what is accomplished today in artificial photosynthesis projects and is grounded on the foundation of our past expertise in this area.^{2-3,6} In case of success, these devices will constitute a real breakthrough in the area, because: they will be the very first hybrid photoelectrodes based on molecules and inorganic semi-conductors mimicking the Z Scheme. The overarching goal is to construct efficient and stable photocatalytic systems capable of reducing CO_2 and oxidizing water or organic substrates into higher-value products. Within this multidisciplinary project, the core tasks will include the synthesis of dyes and multi-component molecular assemblies, their immobilization onto state-of-the-art semiconductor photoelectrodes (e.g., silicon), and the detailed evaluation of their photocatalytic properties. While semiconductor electrodes will be provided by our collaborators, the hired postdoctoral researcher will focus on molecular synthesis, functionalization, grafting, and photoelectrochemical characterization. The central research effort will thus span molecular synthesis,

catalysis, and photoelectrochemistry, ultimately converging on the development of next-generation hybrid photoelectrochemical cells.

This project is funded by PEPR LUMA under the SYNFLUX-LUMICALS Moonshot project and is developed in collaboration with several laboratories in France.⁷ More specifically, the project will be conducted in the CEISAM laboratory at Nantes University and will focus on organic and coordination chemistry of molecules followed by electro- and photo-catalytic characterizations.

References:

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3. (a) V. Nikolaou; C. Govind; E. Balanikas; J. Bharti; S. Diring; E. Vauthey; M. Robert; F. Odobel, *Angew. Chem. Inter. Ed.*, 2024, 63, 13, e202318299; (b) V. Nikolaou; G. Charalambidis; G. Landrou; E. Nikoloudakis; A. Planchat; R. Tsalameni; K. Junghans; A. Kahnt; F. Odobel; A. G. Coutsolelos, *ACS Appl. Energy Mater.*, 2021, 4, 9, 10042-10049.
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5. L. Favereau; A. Makhal; Y. Pellegrin; E. Blart; J. Petersson; E. Göransson; L. Hammarström; F. Odobel, *J. Am. Chem. Soc.*, 2016, 138, 11, 3752-3760.
6. (a) H. Ichou; L. Choubrac; G. Suna; D. Sarkar; P. J. Marques Cordeiro Junior; S. Diring; F. Pineau; J. Bonin; N. Barreau; M. Robert; F. Odobel, *Angew. Chem. Inter. Ed.*, 2025, 64, 8, e202423727; (b) P. B. Pati; R. Wang; E. Boutin; S. Diring; S. Jobic; N. Barreau; F. Odobel; M. Robert, *Nature Commun.*, 2020, 11, 1, 3499; (c) F. Odobel; P. B. Pati; M. Abdellah; S. Diring; L. Hammarström, *ChemSusChem*, 2021, 14, 14, 2902-2913.
7. <https://www.pepr-luma.fr/en/projet/synflux-lumicals-en/>

Skills/Qualifications :

The main aim of this project is to first synthesize molecular systems (dyes, catalysts) and then to implement them on photoelectrode to build a photoelectrochemical cell. The candidate will be involved in the following tasks:

- 1- Synthesis of molecules (phthalocyanines, porphyrins, rylene bisimides and polypyridine derivatives for ex.) requiring good skills in organic synthesis and coordination chemistry.
- 2- Immobilize these molecular systems on electrodes of semiconductors and measure their photocatalytic performances upon light irradiation.
- 3- Presentation of results at progress meetings with the consortium.
- 4- Writing of reports (bibliography and experimental results).

A highly motivated and skilled candidate in organic chemistry with experience at the frontier of molecular synthesis and material science is actively searched for this position. For example, a previous experience with photoelectrochemistry would be a real asset. Good communication skills either in English (both written and oral) are required. Owing to the multidisciplinary aspect of the project, curiosity and motivation to acquire knowledge in different fields at the frontier of chemistry is also needed.

The working languages are English or French.

To apply (and/or for more information), please send a cover letter outlining your motivation, a complete CV with the list of publications and at least two references to Dr. Fabrice Odobel (fabrice.odobel@univ-nantes.fr).

Work context

The project will be carried out in Dr. Fabrice Odobel' group located in the CNRS laboratory CEISAM, which is part of Nantes University in France. The team is composed of 3 permanent researchers, 4 post-doctorates and 2 PhD students.

The CEISAM Institute ("Interdisciplinary Chemistry: Synthesis, Analysis, Modelling") encompasses all the research activities carried out in the area of molecular chemistry in Nantes and its surroundings. The CEISAM Institute is located on the Faculty of Science campus of the University of Nantes. CEISAM has about 3,000 m² of space, and hosts about 140 researchers with different backgrounds, specialized in the fields of chemistry, material sciences, hybrid materials, electrochemistry, photochemistry, methodological developments in analytical chemistry, and molecular modeling.

Benefits

As an employee in France, you will have full access to an optimal health service.

The gross salary is between 2 833€ à 3 257€ per month depending on the experience.