

11 March 2025

PhD contract offer

New membranes loaded with carbon/MOF hybrids for liquid and gas phase applications

General information

Workplace: Epinal, France

Type of contract: PhD contract funded by Horizon Europe Marie Skłodowska-Curie Doctoral Training Network

Contract period: 36 months

Expected date of employment: Between 1 August (soonest) and 1 October 2025 (latest)

Proportion of work: Full time

Remuneration: About 4557 € gross/month, i.e., about 2630 € net/month

Desired level of education: Master's degree in materials science or chemical engineering

Experience required: -

Subject description

The work will be carried out within the framework of the Horizon Europe Marie Skłodowska-Curie Doctoral Training Network PhotoBrane (*"Photo-tuning membranes for molecular separation"*). PhotoBrane is at the forefront of innovation, developing next-generation photo-tunable and photo-regenerable membranes. These ground-breaking membranes potentially transform industries such as energy conversion, biomedical applications, water purification, and environmental protection by enhancing selectivity, permeability, and operational longevity.

The proposed doctoral research project, *"New membranes loaded with carbon/MOF hybrids for liquid and gas phase applications"*, will aim to:

- (i) Prepare MOF/carbon hybrid materials of high surface area to be used as fillers in mixed matrix membranes (MMMs);
- (ii) Prepare and apply such MMMs for water treatment;
- (iii) Incorporate dyes in MOF/carbon hybrids, depending on pH and temperature;
- (iv) Develop photo-responsive MMMs;
- (v) Explore applicability of the Ideal Adsorbed Solution Theory (IAST) to describe the adsorption equilibria of gaseous binary mixtures.

The expected results are:

- (i) Availability of new MOF/carbon hybrid materials with enhanced surface area and adsorption capacity thanks to special interactions between metals and sp² aromatic domains, guiding the growth of MOF and thus providing improved porous structures;
- (ii) New MMMs based on such hybrids, incorporating dyes or not, and with various surface properties depending on those of the fillers, which can be made either very hydrophilic or not, depending on the chemical post-treatments;
- (iii) Understanding changes in porosity, surface properties and performance over the lifetime of MMMs for gas- or liquid-phase applications, with and without light;
- (iv) Understanding the limits of IAST and potentially develop it to account for photo-tuning;
- (v) Demonstration of photo-tunable molecular sieving MOF/carbon hybrid MMMs.

Keywords: Nanoporous carbons; MOFs; Mixed matrix membranes; Porosity; Photo-tunable molecular sieving.

Themes / Context

Inspired by the switching of optical and transport properties in liquid crystalline polymers under electrical [1] or thermal stimuli [2,3], as well as pioneering research on photo-tunable polymer membranes [4], zeolites [5], and MOFs [6-8], the PHOTOBANE project integrates photo-switchable molecules into molecular sieves and polymers. A consortium team has already demonstrated that visible light can modulate absorption and release in core-shell MOF particles using fluorinated azobenzenes [9]. However, MOFs have certain limitations, including thermal and chemical stability, cycling performance, and sensitivity to trace contaminants. To address these challenges, this thesis will focus on hybridizing MOFs with nanocarbons, aiming to enhance performance and improve properties through synergistic effects and interfacial property engineering [10].

Supervision Details

The research will be conducted at the Epinal site of the Institut Jean Lamour (ENSTIB Campus). The supervision will be complementary, combining expertise in composite material synthesis and characterization with knowledge of physicochemical properties and related modeling.

Scientific, Material, and Financial Conditions of the Research Project

The research will be carried out in fully equipped laboratories, with a doctoral contract secured.

Research Dissemination, Publication, and Intellectual Property Rights

The results will be disseminated through publications in international journals and presentations at specialized conferences. If deemed relevant by the research team, patent applications may also be considered.

Planned Collaborations

As this research is part of a European collaborative network, international partnerships will form the foundation of the consortium the candidate will join. The thesis will involve multiple research stays at partner universities, enabling the candidate to work and receive training on the following topics:

- **Friedrich Schiller University Jena (FSUJ, Prof. B. Dietzek-Ivanšić, Germany), Months 12–13 (2 months):** Study of the photophysics of photo-switchable membranes.
- **Consiglio Nazionale delle Ricerche (CNR, Dr. E. Tocci, Italy), Month 16 (1 month):** Collaborative work on the molecular modeling of gas separation membranes.
- **Polymer Libraries GmbH (POLLIB, Dr. C.G. Sanchez, Germany), Months 24–25 (2 months):** Training in the development of commercial polymers and structural motifs for crosslinking.
- **Leibniz Institute for Photonic Technologies (IPHT, Dr. M. Presselt, Germany), Months 26–28 (3 months):** Joint research on quasi-2D photo-responsive membranes.

Whenever necessary, leading experts will be consulted to address experimental, theoretical, or modeling-related challenges. Depending on the circumstances, additional research stays at partner laboratories in France or abroad may be considered.

For more information, please consult <https://euraxess.ec.europa.eu/jobs/323733>

References

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7. K. Müller, L. Heinke, et al., Chem. Eur. J., 2017, 23, 5434-5438
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10. S. K. Gebremariam, et al., J. Environ. Chem. Eng., 2023, 11, 109291.

Work context

Supervision will take place at the Epinal site of the Institut Jean Lamour (ENSTIB Campus). It will be complementary in terms of skills in composite, carbon and MOF materials synthesis and characterization, and in physicochemical properties and associated modeling.

The team enjoys one of the largest experimental platforms of the Greater East French Region dedicated to the preparation and characterization of complex materials.

Skills

The candidate will join a research team specialised in materials science, the "Biosourced Materials" team of the Institut Jean Lamour (IJL, UMR CNRS 7198), housed in the premises of ENSTIB, in Epinal. He/she will need to have a very strong background in materials science, chemistry or chemical engineering, but knowledge of membranes and related processes will be particularly appreciated. The candidate will have to demonstrate a great ease with the techniques of preparation (spin-coating, doctor blade coating, ...) and characterization of materials (mechanical properties, adsorption and permeability measurements) on which he/she will be trained to become quickly autonomous. Knowledge of porosity determination and associated properties will be a real plus. He/she will have to be dynamic, curious and persevering in order to carry out the multiple syntheses, characterisations, tests and interpretations of the results, and to demonstrate the ability to work in a team.

Please note: not all applications are necessarily eligible. Indeed, as this is a PhD thesis within the framework of a European doctoral network, the European mobility rule stipulates that **applicants must not have resided or carried out their main activities (such as work or study) in the country of the hosting organization for more than 12 months in the 3 years immediately prior to the application deadline, and must not have already obtained a doctoral degree.**

Applications that do not meet these conditions will not be considered.

Constraints and risks

The position you are applying for is located in a sector relating to the protection of scientific and technical potential. It therefore requires, in accordance with the regulations, that your arrival be authorized by the competent authority of the Ministry of Higher Education, Research and Innovation.

About Institut Jean Lamour

The Institut Jean Lamour (IJL) is a joint research unit (UMR 7198) of CNRS and Université de Lorraine. The IJL is focused on materials and processes in science and engineering, and covers activities in condensed matter physics, materials, metallurgy, plasmas, surfaces, nanomaterials and electronics. The IJL staff consists of 183 researchers/lecturers, 91 engineers/technicians/ administrative staff, 150 doctoral students and 25 post-doctoral fellows. The IJL has active partnerships with 150 companies and our research groups collaborate with researchers from more than 30 countries throughout the world. The IJL's exceptional instrument platforms are spread over 4 sites; Epinal is one of them.

Application

Only high quality applications will be considered: Master 2 average $\geq 14/20$, 1st quartile, international experience required. Applicants who do not meet these requirements are asked not to submit an application.

Women are especially encouraged to apply. Applications should consist of a cover letter including a motivation statement, a curriculum vitae, a list of publications, the contact details of two references, together with diploma copies and/or marks obtained during the Master degree, and send it to:

alain.celzard@univ-lorraine.fr

vanessa.fierro@univ-lorraine.fr

Then, interviews will be organised and visits of the labs will be possible on request.