

## Job offer – PhD in Chemistry of Materials and Heterogeneous Catalysis

**Research Project Short Title as Submitted to CEFIPRA:** “Development of borophene-based catalysts for water remediation”

**Principal Investigator contact:** “DHAINAUT Jérémy, [jeremy.dhainaut@univ-lille.fr](mailto:jeremy.dhainaut@univ-lille.fr)”, University of Lille

**Reference Number of the Job Offer:** IFI\_CEF\_24\_04

### Project description

- **Keywords:** Borophene, metallic nanoparticles, piezo-photocatalysis, environmental catalysis, organic micropollutants, water

- **Context:**

Modern agriculture, industry and households rely on the use of large quantities of chemicals, and a significant part of these chemicals ends up in the hydrologic cycle. The World Health Organization estimates that “about 4.5 billion people use a sanitation system that does not adequately protect either their family or the downstream community from harm”. Therefore, practical solutions that are easy to implement are needed to address this concern, to complement wastewater treatment plants. In the case of organic compounds, it is possible to either capture them by adsorption or to degrade them into non-toxic molecules. The latter approach is dominated by advanced oxidation processes (AOP), including photocatalysis. However, the fast recombination of photogenerated charge carriers is a severe limitation. Thus, there is a keen interest in limiting this recombination.

- **Abstract of the Research Project:**

Like graphene, 2D boron sheets known as borophene present unique physico-chemical properties such as high thermal conductivity, low optical band gap, high mechanical properties and high external surface area. Recently, our team have shown that borophene promotes the generation of radical species under ultrasonic vibrations (US) following the generation of a piezoelectric potential which separates the charge carriers. Especially, within 6 minutes under US, any tested dye was efficiently degraded. However, the degradation of pharmaceutical compounds and pesticides proved to be more difficult. Hence, this research project aims at developing novel photocatalysts based on borophene.

- **Scientific Objectives of the Project:**

First, metal oxide nanoparticles will be deposited on the surface of borophene nanosheets in order to form semiconductor heterojunction photocatalysts. The photocatalysts will be fully characterized by coupling various spectroscopic techniques as well as high-resolution and chemical characterization. Notably, the morphology of the as-prepared borophene will be tuned according to the literature, and its impact over the piezoactivity will be assessed by piezo force microscopy (PFM).

In a subsequent step, these materials will be applied to the oxidation of selected organic contaminants in water under photo- and/or US-irradiation. Emphasis will be given to identifying the decomposition products and involved catalytic mechanisms as well as their toxicity. After test, the catalysts will be recovered and characterized again in order to evaluate their long-term deactivation and possible reactivation.

Finally, the best catalyst will be applied in real conditions, for the degradation of organic contaminants in wastewater recovered downstream a hospital and hence enriched in antibiotics and other pharmaceuticals. The effect of ions present in the water will be especially investigated.

- **Methodology and Timeline of the Project:**

During the first year, the PhD student will work mainly in India under the supervision of Prof. Kushwaha (MNIT Jaipur) and will prepare borophene nanosheets of different morphologies. Then, he will come to France (UCCS – Univ. Lille) to prepare and characterize the photocatalytic catalysts. The photocatalytic tests will be performed at UCCS, in collaboration with LASIRE, a laboratory specialized in the analysis of contaminant traces in water. The toxicity measurements will be conducted at MNIT Jaipur by the third year, as well as the cycling experiments and characterization of the used catalysts.

### Candidate profile

- Only Indian candidates or candidates with a research experience in India are eligible; French candidates are not eligible
- Applicants for PhD must have a master's degree (or be in the process of obtaining one) or have a University degree equivalent to a European Master's (5-year duration) to be eligible at the time of the deadline of the call;
- No competences in French language is required
- Candidate competences: good communication and teamwork skills, critical thinking, efficient time and project management, adaptability and creativity, reasonable writing and presentation skills
- Candidate know-how: synthesis of inorganic materials, use or at least general knowledge of standard characterization techniques for materials (FTIR, Raman, XRD, SS-NMR, microscopy *etc.*), use or at least general knowledge about UV-visible spectrophotometry
- Expected starting date: **01-10-2024**

### How to candidate ?

Documents to be provided :

- i. A cover letter (reasons for the candidature, professional project ...) max 2 pages
- ii. A copy of the master's degree or a proof of the program followed (and expected date of end) OR A copy of the PhD degree or a proof of the PhD program followed (and expected date of defense) max 1 page
- iii. A copy of results for previous scholarship (max 3 pages)
- iv. International curriculum vitae (max 2 pages)
- v. Two letters of recommendation: one from any Indian institution and one from the French institution planned to host the candidate –mandatory- (max 2 pages)
- vi. All should be submitted within 1 pdf file of no more than 10 pages.

Applications should be submitted to the following email address: [msi@ifindia.in](mailto:msi@ifindia.in) mentioning the reference number of the Job offer clearly.

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**Candidates are requested to contact the French scientific principal investigator of the project before submission. A recommendation letter from the scientific principal investigator is mandatory.**

**Benefits:**

- Monthly allowance of 1710 euros for PhD
- Travel allowance
- University fee
- Carte de séjour fee
- Campus France management fee
- Registration to the French social security scheme

**Selection process:**

Selection is made by a dedicated selection committee of at least 4 persons. Decisions will be transmitted by the Embassy of France to CEFIPRA. **No consideration will be given for candidates with no recommendation letter from the French institution.**

**Criteria for applicants’ selection:**

Academic excellence

- Excellence of the Academic background, Academic records, Honors, Letters of support, Participation to international research projects, exchange programmes and conferences.

Motivation and qualities

- Academic maturity: appropriation of the thesis project (stakes and contexts) • Quality of the presentation (oral expression, skills for synthesis, English level) • Maturity of the professional project: capacity to project her/himself within five years in terms of career development.

**About CEFIPRA:**

Indo-French Center for the Promotion of Advanced Research (CEFIPRA/IFCPAR) is an Indian body which promotes scientific cooperation between France and India in advanced fields of Science and Technology. It is supported by the Department of Science and Technology, Government of India and the Ministry of Europe and Foreign Affairs of the French government.