Funded by the European Union

FunctiGlass

Project title DC7: Optical sensor for organophosphorus pesticides detection and immobilization

Recruiting institution: CNRS (France)

Background
Over the past four decades, **glass, glass-ceramics and composites** have contributed to the most advanced socio-economic breakthroughs as high-tech materials. To compete with emerging economies such as China and India, the European glass sector must strive for product leadership by investing more in research and innovation to develop new materials and train specialists for a competitive but promising market.

Contributing to this challenge is the main objective of the 'Structured functional glasses for lasing, sensing and health applications' (FunctiGlass) project, dedicated to **advanced high-tech materials for three sectors: light sources, sensors and biological applications.**

FunctiGlass, coordinated by CNRS, is a unique interdisciplinary research and training programme with a **double degree** as part of Horizon Europe's Doctoral Networks (Marie-Skłodowska Curie Actions, project 101169415). It will train 11 doctoral candidates who will take part in a joint research training programme based on **very close cooperation between academia and industry.** It will ensure that the trainees are exposed to 11 academic environments (universities and research institutes) and 9 non-academic environments (industry and SMEs) representing 9 different countries. **Each PhD candidate will be supervised by two academic tutors from different countries (spending her/his time between both units) and one mentor (industrial partner)** to ensure cross-sector knowledge sharing and the acquisition of transferable skills with a focus on

entrepreneurship and innovation. Through the multi-dimensional training of the FunctiGlass programme, the 11 PhD candidates will excel in the future economy by acquiring a multi-dimensional perspective and mindset to become **future leaders in glass science and in particular glass-based nano/micro-structured materials.** Through this programme, they will find their own path of innovation in academia or industry.

The project will create the conditions necessary for the establishment of long-term relationships between the academic and private sectors for the transfer of technologies and skills.

5 institutions will award the double degrees: Université Côte d'Azur (Nice, France), Tampere Universities (Finland), Gottfried Wilhelm Leibniz University Hannover (Germany), University Milano-Bicocca (Italy) and the Institute of Low Temperature and Structure Research, Polish Academy of Sciences (Wroclaw, Poland).

Industrial partners: AOI Tech (France), Corning (France), Fastlite (France), Klearia (France), Else Nuclear (Italy), Nobula3D (Sweden), Nyfors Teknologi (Sweden), Rosendahl Nextrom (Finland), Scout Scientific Outsourcing (Poland).

Other universities involved in the project as partners (not awarding doctoral degrees): University of Cergy-Pontoise (France), University of Gent (Belgium), University of Pardubice (Czech Republic), University of Nazarbayev (Kazakhstan), Umeå University (Sweden).

Description of the PhD project

Organophosphorus (OP) chemicals are a class of compounds that contain phosphorus atoms bonded to organic groups and oxygen. These chemicals are widely used in agriculture as pesticides and in industrial applications, such as in flame retardants, plasticizers, and lubricants. These chemicals are highly toxic and can cause neurotoxicity due to their ability to inhibit acetylcholinesterase enzyme activity. Furthermore, OPs are persistent in the environment, often contaminating soil, water, and air, which can lead to long-term ecological damage. Traditionally OP compounds are analyzed using complex, costly, and time-consuming chromatographic techniques (HPLC, GC), necessitating that samples are transported to a dedicated laboratory (with the problem of sample preservation and conservation) and making impossible in-situ measurements. To overcome this limitation, the development of sensing methods has attracted attention since it could help the development of a portable and low-cost device allowing a rapid and on-site detection of OP compounds (Kumar et al. 2015). Among them, the use of enzymes (acetylcholinesterase, alkaline phosphatase, organophosphorus hydrolase, etc.) as sensors for pesticide detection has been widely studied, but these methods cannot substitute for chromatographic analysis due to their limited sensitivity and selectivity (Van Dyk et al. 2011). In addition, enzymatic sensor efficiency is affected by pH, temperature, and humidity, making these sensors unsuitable for some applications.

Electrochemical non-enzymatic sensors attracted interest due to their low cost, short analysis duration, and very low detection limits. The determining factors for the sensitivity of electrochemical sensors are the conductivity properties of the material used. Among these materials, graphene, carbon nanotubes, metal and metal oxide nanoparticles, nano-polymers, metal organic frameworks (MOF), and metal imprinted polymers (MIP) have been investigated, but the techniques

need to be improved, in particular for a better sensitivity, selectivity, and stability of electrochemical performance (Zhou et al. 2023).

Optical signals from nanomaterials have been explored as a potent detection option for OP. The enzyme-based optical biosensing consist in measuring the optical signal of a substrate (nanomaterial) in the presence and in the absence of OP. In the absence of OP, the substrate hydrolyses and causes a response to the optical signal. In the presence of OP, the enzymatic activity is inhibited so that the hydrolysis of substrates is inhibited, resulting in opposite optical signal response. Depending on the substrate, photoluminescence, fluorescence, chemiluminescence, electrochemiluminescence or colorimetry techniques can be used (Gong et al. 2022).

The objective of the PhD work is to develop an optical probe for the rapid detection of OPs with sensitivity at least comparable to currently used and time-consuming methods. It is planned to create an optical detector composed of optical fiber co-functionalized with metal organic frameworks (MOFs) as absorbers and/or nanoparticles of gold, silver, or other metals used for plasmonic Raman signal enhancement. The use of colorimetric methods in the UV-Vis spectroscopy range is also not excluded. Another objective of the study is to understand the nature of interactions of selected OP molecules with MOF-type substrates, metal nanoparticles, and/or optical fiber.

The project plan includes:

1) Selection of OPs and MOF-type material
2) Synthesis of MOF without and with metal nanoparticles, impregnation with OPs
3) Determination of physicochemical properties in order to select the sensing method
4) Investigations of the interactions of the tested OPs with substrates
5) Measurement, analysis, and evaluation of the parameters of the fabricated sensors.

The following experimental methods may be used: X-ray diffraction (XRD), IR/Raman spectroscopy, electron spectroscopy (absorption, emission), gas chromatography coupled to mass spectrometry (GC-MS), microscopic techniques (SEM), elemental analysis, zeta potential, nuclear magnetic resonance of 31P (NMR), and/or surface area (BET).

Kumar, P., Kim, K. H., & Deep, A. (2015). Recent advancements in sensing techniques based on functional materials for organophosphate pesticides. Biosens. Bioelectron., 70, 469-481.
Van Dyk J., Pletschke B. (2011). Review on the use of enzymes for the detection of organochlorine, organophosphate and carbamate pesticides in the environment, Chemosphere, 82(3), 291-307.
Zhou, C., Feng, J., Tian, Y., Wu, Y., He, Q., Li, G., & Liu, J. (2023). Non-enzymatic electrochemical sensors based on nanomaterials for detection of organophosphorus pesticide residues. Environ. Sci.: Adv., 2(7), 933-956.
Gong, C., Fan, Y., & Zhao, H. (2022). Recent advances and perspectives of enzyme-based optical biosensing for organophosphorus pesticides detection. Talanta, 240, 123145.

Practical information

- Contract will start in October 2025, for 4 years.
- Recruiting institution: CNRS (France)
- Doctoral school: Doctoral School for Fundamental and Applied Sciences (ED SFA), Université Côte d'Azur (France)

- Industrial mentor: KLEARIA
- Host laboratory: Institut de Physique de Nice (France)
- Supervisor: Ass. Prof. Charlotte Hurel
- Co-host laboratory: Institute of Low Temperature and Structure Research, Polish Academy of Sciences (Poland)
- Co-supervisor: Dr Maciej Ptak
- Secondments: Tampere University (Finland) (1 month), Nazarbayev University (Kazakhstan) (1 month)
- The gross monthly salary based on the MSCA rules varies between 1920€ and 4063€, depending on the country of recruitment.
- The student will also receive a mobility allowance and a family allowance (depending on family situation) of up to 600 € and 495€ per month, respectively.

Recruitment criteria

- MSCA Mobility Rule: researchers must not have resided or carried out their main activity
- (work, studies, etc.) in the country of the recruiting beneficiary for more than 12 months in the 36 months immediately before their date of recruitment
- All researchers recruited in a DN must be doctoral candidates (i.e. not already in possession
- of a doctoral degree at the date of the recruitment)
- Possession of a Master's degree before the start date of the contract
- Scientific interest to fit the PhD project
- Fluent (oral and written) English skills as the project operates in English
- Knowledge of the language of the host countries may be considered a merit
- Team-mindedness

Criteria specific for PhD7

- Good knowledge in optical spectroscopy, material sciences, surface physico-chemistry
- Basic knowledge in physics, surface functionalization, surface grafting
- Experience in chemical lab and/or material synthesis
- Master degree in physics, chemistry, material engineering, and related sciences

Application

Documentation to be sent in by the applicants

- Application form completed
- CV + Letter of motivation
- Contact of two reference persons to be contacted by the selection committee (name, relation to the candidate, e-mail address and phone number)
- Complete list of publications and academic works
- Proof of language proficiencies
- Proof of master diploma or 2024 registration to master degree

How to apply?

- Download application form and fill it indicating all the offers you wish to apply for
- Send your application by email to **recruit@functiglass.eu**. The title of your email MUST be:

FunctiGlass PhD x, x, x application (x, x, x being the number(s) of the PhD position(s)you want to apply for)
- Be careful to join all documentation required (see list above)

Deadline for application
15th April 2025

Contact
contact@functiglass.eu