International thesis offer

Co-supervisors : Wojciech WRÓBLEWSKI (Faculty of Chemistry, Warsaw University of Technology, Warsaw – Poland) and Jérôme LAUNAY (LAAS-CNRS de Toulouse – France).

Period : autumn 2024 to autumn 2027.

Location : work carried out between France and Poland (mainly in France).

Thesis grant : 2,000 to 2,300 euros gross per month

Contacts : wojciech.wroblewski@pw.edu.pl and jlaunay@laas.fr

Description of thesis topic:

Development of electrode and transistor type microsensors for nitrate ion detection in freshwater and integration of an all-solid-state reference electrode.

With the development of intensive agriculture and the massive use of nitrogen fertilizers and slurry, surplus nitrates contained in soils either leach into groundwater or run off into nearby watercourses, constituting a major source of pollution. In France, 66% of nitrates in surface and groundwater come from intensive farming. Legislation sets the quality limit for nitrates in drinking water at 50 mg/L. However, nitrate concentrations still exceed this limit in some catchment areas. In addition, to avoid eutrophication, nitrate levels in the aquatic environments concerned must not exceed 15 mg/L.

Various methods can be used to determine nitrate levels in water, soil or food, including UV spectroscopy, chromatography and capillary electrophoresis. Once again, most of these methods require expensive equipment and complex, meticulous sample preparation.

Electrochemical methods are becoming increasingly popular, as they offer a number of advantages. They are non-destructive to the sample, easy to miniaturize, inexpensive, simple, fast and high-performance in terms of sensitivity and selectivity. They can be used for colored or turbid samples. In this PhD project, we propose to develop two main types of electrochemical method for nitrate detection: amperometric, using electrochemical microcells, and potentiometric, using ion-sensitive transistors.

The work will involve defining and integrating functionalization layers (ionophores, ion exchangers, etc.) in polymeric matrices to optimize nitrate ion detection properties: sensitivity, selectivity and above all drift. In addition, interfacial transduction layers will need to be studied to extend the life of these sensors, using PEDOT or Polypyrrole matrices with the addition of carbonaceous material such as carbon nanotubes.

This type of microsensor has been developed in the past by the MICA team at LAAS in France. And during two thesis defenses (M. Joly - 2018 and C. Béné - 2023), Mr. Woblewski participated as a rapporteur to provide his expertise on the types of functionalization envisaged. For these two PhD projects, one of the issues was the detection of nitrate ions: either in the soil or in freshwater. An international collaboration will enable us to combine skills in detection microsystems and functionalization chemistry within the framework of a doctoral co-supervision.

It should be noted that this work will have to be completed by the study and realization of a stable, all-solid reference electrode, in order to achieve a fully integrated, autonomous microsystem. Measuring nitrate ion concentration will require a stable and reliable polarization of the microsensor.