PhD position 2024-2027 - Marseille, France

Electroenzymatic biosensor for H_2 detection

Laboratory: Bioenergetics and Protein Engineering (BIP), CNRS, Aix-Marseille University - https://bip.cnrs.fr/groups/bip08/

Context : Within the current challenge of irreversible climate change, the search for CO_2-neutral energy sources and carriers is essential. Thanks to its transient storage and restitution during peaks of energy needs via fuel cells, hydrogen appears to be a sustainable solution. However, being a light and explosive gas, hydrogen represents significant risks when stored in large quantities. The installation of reliable, sensitive and miniaturized sensors is therefore required to detect possible leaks. In nature, hydrogenases are very efficient and selective enzymes for H_2 oxidation. We have shown that the membrane-bound Ni-Fe hydrogenase extracted from the bacterium *Aquifex aeolicus* has many of the essential characteristics to meet the requirements of an electrochemical H_2 sensor.

Research description : Capitalizing on our fundamental knowledge of hydrogenase-based electrodes, this Ph.D position will aim at designing a sensitive and miniaturized H_2 biosensor in different environmental conditions. In particular, it will address i) How to tune the immobilization of the enzyme toward the most favorable H_2 oxidation catalysis under the operating conditions required by the H_2 detection biosensor; ii) Which methodologies can be developed in order to overcome H_2 mass transport limitation; iii) How to determine the relationship between the enzyme surface coverage, its spatial distribution at the electrode surface and the enzymatic activity. To answer this question *in situ* and *operando* methods will be implemented, and in particular confocal fluorescence microscopy coupled to electrochemistry; iv) How to increase the stability of the bioelectrodes under storage and turnover. Various parameters (purity and origin of the enzyme, T°, ionic strength, local pH, protection by additives in solution and/or on the electrode) will be evaluated, as well as different electrode structuration and chemical functionalities able to increase the stability of the immobilized enzyme while maintaining an activity compatible with the detection of H_2; v) What is the impact of the geometry of the biosensor and its miniaturization on its performance. Different sensor geometries will thus be produced by 3D printing, making it possible to bring H_2 in dissolved form in a buffer electrolyte but also in gaseous form.
In addition to the applicative proof of the enzymatic sensor, the research carried out as part of the thesis project will improve fundamental knowledge on enzymatic behavior in different confined environments. It will also make it possible to bridge the gap with past developments in the laboratory on enzymatic noble metal free fuel cells, by ultimately considering the self-powering of the sensor.

Ph.D skills: The candidate should have a Masters' degree in chemistry, with major interest in analytical chemistry. Background/interest in electrochemistry, in 3D printing, and willing to work in a multidisciplinary environment are highly welcome.
This Ph.D position is co-funded by Aix Marseille University (AMU) and "Agence-Innovation-Défense "(AID). European, UK and Swiss nationals can apply.

Applications: Candidates are invited to submit their CV, a motivation letter, copies of academic transcripts and degrees, and two recommendation letters by email to Elisabeth Lojou (lojou@imm.cnrs.fr).
Dead line 10th May 2024