Biomimetic Polymeric Receptor-based Sensor Systems for Study and Monitoring of Wellbeing States

Summary

The overall objective of the PhD study is to develop sensing devices by implementing Molecularly Imprinted Polymers (MIPs) as robust, low-cost biomimetic receptors for minimally invasive and noninvasive measurement of molecular biomarkers of wellbeing states, e.g. stress. The study addresses the urgent need for wearable and point of care (PoC) devices for noninvasive monitoring of stress-related disorders. It aims to overcome the limitations of current testing devices, particularly their restricted capability to analyze complex samples and the use of labile biological receptors as recognition elements. The resulting sensing devices are expected to provide an affordable and easy-to-use analytical tool capable of accurately analyzing biological fluids, such as sweat, in a noninvasive manner.

Research field:	Chemical, materials and energy technology
Supervisors:	Dr. Vitali Sõritski Dr. Jekaterina Reut
Availability:	This position is available.
Offered by:	School of Engineering Department of Materials and Environmental Technology
Application deadline:	Applications are accepted between June 01, 2024 00:00 and June 30, 2024 23:59 (Europe/Zurich)

Description

There is an increasing demand for wearable, PoC devices for non-invasive analysis capable of stress monitoring by offering minimal disruption to daily routines while providing instant and continuous assessments of an individual's psychological state. Electrochemical biosensors are being actively researched due to their cost-effective fabrication and the potential for miniaturization of the instrumentation making them ideal for use in PoC wearable devices.

The use of Molecularly Imprinted Polymers (MIPs) as robust biomimetic receptors in sensing devices is an attractive approach to overcome limitations associated with biological recognition elements. Through the process of molecular imprinting, MIPs are designed to bind target molecules by creating specific molecular cavities within a polymeric network. These cavities accurately mimic the size, shape, and chemical functionalities of the target molecules, resulting in a highly specific and efficient binding capability. MIPs offer a unique combination of selectivity and affinity comparable to biological receptors, while also providing additional benefits. These benefits include enhanced chemical and thermal stability, cost-effectiveness, reproducibility, and an animal-free fabrication process. The synergy of MIP strategies for creating robust biomimetic receptors and wearable and PoC sensing devices can further expand the significance and applicability of these technologies, ultimately leading to more efficient and accurate monitoring of stress-related states.

The objective of this PhD project is to develop affordable synthesis approaches that enable the generation of MIPs with selectivity towards molecular biomarkers of wellbeing states e.g. stress biomarker - cortisol. These approaches should be compatible with the efficient integration of MIPs into a wearable sensor platform (preferably, with electrochemical transduction mechanism), facilitating reproducible and rapid analysis of complex biological samples such as sweat in a noninvasive manner. The project also aims to establish appropriate data processing methods enabling efficient interpretation of the data generated by MIP sensing device.

Responsibilities and (foreseen) tasks

- to actively participate in the experimental work:

- the rational selection of functional monomers using computational modeling and spectroscopic analysis;

- selection of target biomarkers based on relevant literature search;

- finding of an optimal polymerization method and an efficient procedure for target molecule removal to produce MIP;

- adapting the synthesis methods to generate MIP on a suitable wearable sensor platform;

- rational improvement of MIPs in terms of affinity and selectivity towards the chosen target analytes;

- study of the analytical performance of the prepared MIP sensor in the relevant media, e.g. sweat samples as well as optimization of sample collection and pretreatment procedure.

- to collaborate with internal and external research groups;
- to communicate results at meetings, conferences, and write reports and publications.

Applicants should fulfil the following requirements:

- MSc in the field of chemistry, analytical chemistry, materials science, or in a related field
- a clear interest in the topic of the position
- excellent command of English (Level B2 or higher)
- strong and demonstrable writing and analytical skills

We are looking for top motivated candidates having practical experience in polymer synthesis, electrochemistry, chemo- or biosensors preparation and study. Furthermore, we expect good laboratory skills and the ability to work independently, the ability to write up results of your own research and prepare for presentations. The top candidates for the post will be interviewed and asked to present their scientific work and experience.

The following experience is beneficial:

- Programming in Matlab, Python
- Working knowledge of data analysis and graphing software Origin (OriginLab Corporation)
- Knowledge of electrochemistry
- Knowledge in the machine learning

Important: The candidate should submit a tentative research plan for the topic, including the overall research objectives. In the plan, the candidate should avoid text with general formulations prepared using AI-assisted tools. The candidate's ability to compose a consistent plan that expands on the listed research questions and tasks and proposes theoretical lenses will be highly valued by us.

About the Laboratory of Biofunctional Materials

The Laboratory of Biofunctional Materials of the Department of Materials and Environmental Technology develops smart sensing functional materials to propose solutions with considerable potential impact on essential areas of human life such as environmental protection and medical diagnostics. Employing the molecular imprinting technology, the group designs and synthesizes polymeric materials so called Molecularly Imprinted Polymer (MIP), which, thanks to their synthetic nature, possess excellent chemical and thermal stability and are associated with reproducible, cost-effective fabrication. MIPs can be easily integrated with a variety of sensor platforms and allow, thus, label-free detection of a target analyte with high sensitivity and selectivity. The laboratory has succeeded in developing the MIP-based sensors capable of determining various antibiotics (sulfamethizole, amoxicillin, erythromycin) in aqueous media as well as clinically relevant compounds such as immunoglobulin G, neurotrophic factors (BDNF, CDNF) and viral proteins (SARS-Cov-2 nucleocapsid and spike proteins).

(Additional information)

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