Development of an Electrochemical Multiparametric Sensor for Continuous Monitoring of Cardiovascular Biomarkers

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Heart failure (HF) has been defined as a global pandemic, with 64.3 million people estimated to suffer from it worldwide in 2017 [1]. These figures, however, do not account for the vast number of patients who remain undiagnosed or are misdiagnosed, often due to the absence of continuous, personalized monitoring systems. Therefore, a point-of-care system capable of providing both patients and clinicians with relevant and accurate data on disease progression and severity could greatly enhance clinical decision-making and patient outcomes.

In this context, my doctoral research is framed within the European project IV-Lab, which aims to develop an implantable, multi-sensing device capable of detecting both hemodynamic and biochemical parameters. This work specifically focuses on the development of an electrochemical sensor capable of estimating electrolytes in blood (K^+ and H^+) and, specific cardiac biomarkers (BNP and NT-proBNP).

Significant progress has been made in optimizing potassium and hydrogen ion sensors using commercial carbon and gold electrodes, respectively, obtained from Metrohm. The sensors demonstrated high sensitivities, exceeding 95 mV/mM for potassium and 90 mV/pH for hydrogen ions. Additionally, in collaboration with Dr. César Rodríguez, also from IBEC, I have started to evaluate the antifouling properties of a polymeric hydrogel which is coated onto the potassium sensor to prevent coagulation and signal degradation. While hydrogel deposition techniques continue to be optimized, its presence has been confirmed by contact angle measurements (which decreased from 90° to 40° post-deposition) and surface plasmon resonance (SPR) analysis, revealing a ~15 nm increase in thickness attributable to the hydrogel layer. Future steps include reproducibility testing, full electrochemical characterization, and validation with biological samples.

Furthermore, the novelty of this research involves the development and characterization of an aptabeacon (APTB) for BNP and NT-pro BNP detection. The possible structural folds of the APTB have been computationally analysed and theoretical measurements of its base lengths have been made to ensure a suitable distance between the 5'-thiolated linker covalently bonded to the gold chip and the redox molecule at 3’ with which the APTB is functionalized for electrochemical measurements. The characterization platform consists of an SPR system coupled with a potentiostat, enabling real-time kinetic monitoring of APTB-BNP interactions while simultaneously capturing potentiometric and amperometric data. To date, immobilization of APTB onto the gold surface has been successful, and ongoing work is focused on achieving BNP-specific aptabeacon opening for precise biosensing.

References

[1] Savarese, G., Becher, P. M., Lund, L.H., Seferovic, P., Rosano, G.M., Coats, A.J. (2022). Global burden of heart failure: a comprehensive and updated review of epidemiology. European Society of Cardiology, 3272-3287.