

Electrolyte-Gated Organic Transistors (EGOTs) have acquired in the last decade a growing interest in the scientific community as a novel tool for the determination of relevant biological molecules at low concentration. This feature – in addition with the reduced costs and the low-voltage operations – opens interesting opportunities in the field of Point of Care (PoC) applications, where sensitive but affordable tools are needed for the evaluation of the patient's conditions with a fast response time. The scope of this work is the development of biosensors based on the EGOT technology for the detection of an inflammatory biomarker called Angiopoietin-2 (Ang-2). To do this, different aspects of the final measurement systems are investigated and discussed.

The first major study was focused on the correlation of the electrical bias stress (EBS) induced on the sensors with the stability of their output current. The results of this campaign revealed a strong degradation of the signal with the EBS as the latter triggers unwanted oxidative reactions in the polymer, which create conformational disorder in the backbone of the polymer (thus reducing its overall conductivity). It was also possible to establish the EBS effects are less prominent when using organic semiconductors (OSCs) working in the field-effect regime (i.e., P3HT) rather than in the electrochemical mode (i.e., P3CPT), which was linked to the different ion permeability property of the two kinds of polymer. This difference is further enhanced when the EBS is applied in the pulsed mode: while for P3HT the current drift was a reversible process (i.e., the current can be restored at its original value after a while), the contrary happens when P3CPT is used as OSC.

The second contribution of this work in the field of biosensors with EGOTs is related to the design and validation of a microfluidic platform that avoids the organic material to be contaminated with the analyte to detect, which is a known problem in literature that can affect the readout of the experiments. To achieve this result, an anti-symmetric microfluidic chip was designed with two inlets and three different chambers: one was used for the active gate electrode, one is exploited for the OSC and the last one is used for the reference gate. The finite element simulations demonstrated that the analyte, when injected, reaches only the active electrode chamber and does not diffuse on the transistor region, thanks to the different fluidic resistance paths between the two inlets. Additionally, the reference gate allowed as well to perform differential measurements, which can be an important method to mitigate the possible presence of any signal drift.

Finally, the outcomes of these studies were exploited to prove the feasibility of the specific detection of the inflammatory biomarker Ang-2, which was the requirement from one of the projects sponsoring this work. It was possible to demonstrate the detection of this protein target at a concentration of 500 pM in diluted Phosphate Buffered Saline solution by exploiting EGOTs based on P3CPT as active material. While the medical requirement for clinical validation is still lower (around 50 pM), these first measurements allowed the assessment of the proof of concept of this kind of biosensors, which has still space for improvements that will be implemented in the future in order to achieve the targeted detection limit.