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Electrolyte-gated transistors as label-free biosensors for healthcare applications and for fundamental investigation of biorecognition processes

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Electrolyte Gated Organic Transistors have rapidly emerged as a solid alternative to optical biosensing.[1] They couple the advantages of organic electronic devices (such as the possibility of fabrication on flexible substrates, the well demonstrated biocompatibility of many of the active materials featured in such applications, and the possibility of achieving economically- and environmentally-sustainable fabrication) with those offered by the electrolyte gating scheme, above all the possibility to be operated at voltages <1V, enabled by the high capacitance of the electrical double layers forming at both the gate/electrolyte and channel/electrolyte interfaces.[2]
The two main EGOT architectures, sharing several similarities and differing mostly for the permeability of the active material to ions, are the Electrolyte Gated Organic Field Effect Transistor (EGOFET) and the Organic ElectroChemical Transistor (OECT). We explored both architectures aiming at the ultra-sensitive detection of biomarkers of medical interest, ranging from small molecules to proteins. I will describe some of the most recent examples of EGOT-based label-free detection developed by our group, typically featuring a specific biorecognition moiety immobilized at the gate/electrolyte interface.[3,4]
Eventually, besides serving to detect a biomarker and quantify it, these devices can also be used to provide us with information on both the kinetics and thermodynamics of the biorecognition events that underlie the device response as biosensors. To this end, the dose curve of the biosensor can be fitted to adsorption isotherms to derive the equilibrium association constant K_a and explore its dependance on experimental conditions, and to gain insight into the molecular events that take place at the interface, such as lateral interactions between antibody/antigen couples or formation of multilayers.
Besides the widely explored configuration of EGOT-based biosensors with the specific biorecognition element immobilized on the gate surface, we also explored an alternative architecture, using semiconducting carbon nanotubes (CNTs) dispersed by proteins as active material.[5] In this case, the protein has the twofold aim of making the CNTs water processable and of serving as a channel-confined probe to sense target analytes in solution. Again, the corresponding (6,5)Carbon Nanotube/Protein electrolyte-gated transistor can be then used for screening the affinity of different compounds to the dispersing biomacromolecule.
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