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Affinity driven ion exchange EG-OFET sensor for high selectivity and low limit of detection of Cesium in seawater

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Abstract:

The detection and quantification of Cs^+ in aquatic media are an environmental safety and public health matter, so far limited by the lack of rapid, low cost, low limit of detection and selective analytical tools. Herein we demonstrate the efficient fabrication of a novel electrolyte-gated organic field-effect transistor sensor for the Cs^+ detection in seawater based on the combination of two ultra-thin layers namely poly(3-hexylthiophene) as semiconductor and a single lipids monolayer as dielectric [2,3]. The latter is end-capped with a specific Cs^+ probe based on a calix[4]arene benzocrown ether to ensure the selectivity.

Cs^+ sensing experiments were performed in various conditions, including the presence of competitive ions and/or solutions with very high ionic strength. Interestingly, we clearly evidence that by controlling affinity driven guest/host ion exchange, one can lift the general problem of selectivity encountered in all FET-based ion sensors, reaching selectivity even in highly complex analytes, such as phosphate buffered saline solution or seawater.

Also our ultra-thin transistor structure exhibits, a limit of detection at the attomolar level which corresponds to a 5 folds' magnitude lower than Inductively Coupled Plasma Mass Spectroscopy, the most commonly used technic today (Fig. 2). Such low limit of detection cannot be explained solely by the change in surface potential induced by the capture of ions by the probe; instead we suggest a reorientation of the dipoles moments at the probe level that may propagate on a large distance leading to an enhancement of the surface potential change induced by an initial ion/probe complexation event.

These results pave the way to a generalized monitoring of ions in complexed analytes.

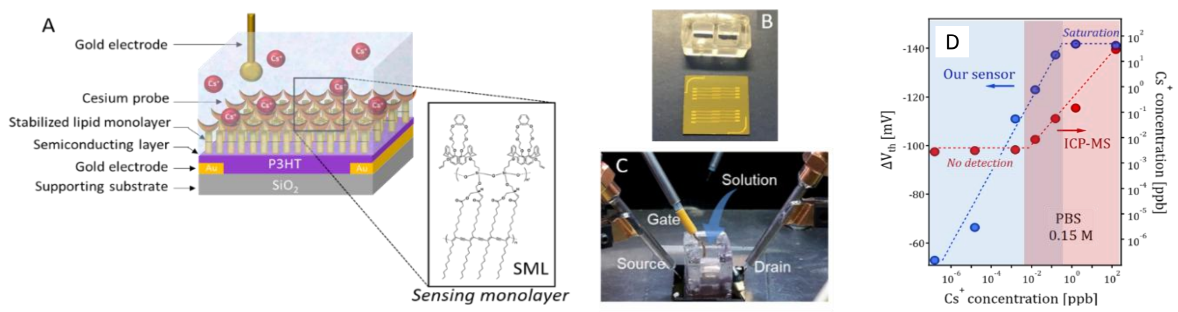

Figure 2 : A) EG-OFET sensor design based on ultra-thin layers of P3HT and engineered lipid monolayer as semiconducting and dielectric materials respectively. The Cesium probe is a calix[4]arene benzocrown ether grafted to the lipid monolayer through a triethoxysilane groups. B) Picture of a chip containing 8 transistors mounted in parallel. C) Picture of the set-up for electrical measurements. D) Comparison of the performances of EG-OFET sensor (in blue) with ICP-MS based detection (red).