Selective electrical detection of Fe(III) ions with a BioFet sensor

Tuyen Duc Nguyen, Racha El Zein, Jean Manuel Raimundo, **Hervé Dallaporta**, and Anne M. Charrier

Aix-Marseille University, CINaM-CNRS,
Campus de Luminy, Case 913, 13288 Marseille, France
dallaporta@cinam.univ-mrs.fr

Abstract

The development of biosensors is a hot issue in the biomedical and environmental fields, whether it is for the diagnostic or the monitoring with the detection of specific markers (molecules, ions, bacteria, viruses, etc…). The development of bioelectronics has been a breakthrough is that field with the development in particular of field effect transistors based biosensors. This type of sensors fulfil many of the nowadays needs in terms of fast response, miniaturization, handiness of the detection process, transportation, high throughput fabrication, and absence of labelling. Here we report the development of such sensor for the detection of ferric ions in solution. Iron is ubiquitous and plays versatile roles in many important metabolic processes, biological materials and environmental samples.

We report here the high performances of a new MOS-type field effect transistor developed for the detection of ferric ions in solution (fig. 1). We demonstrate the detection of ferric ions down to 50 fM (6×10^6 Fe(III) ions or 0.6 fg) in a quantitative way with a logarithmic dependence of the measured signal on the concentration of ferric ions in the analyte (fig. 2 and 3). To our knowledge, this is one of the best sensitivity ever reported for ions using such type of sensors. These performances are due to the unique sensing layer of our transistor. It is based on an end-capped lipid monolayer with a hydroxypyridinone [1-4] derivative. In addition to playing the role of interface between the transduction part of the sensor and the analyte, the lipid monolayer is also used as ultra-thin gate dielectric (3nm thick) in the transistor[5-7]. Using such thin dielectric layer not only improves the sensitivity of the sensor by enhancing the electric field across the transistor gate dielectric but also offers the possibility to work at low operating voltage, which is a major asset for biosensing and the detection of organic molecules. In addition this lipid monolayer appears to be rather inert to ions and does not require passivation to improve the specificity. Both specificity and sensitivity of the sensor also rely on the hydroxypyridinone derivative which shows to be highly specific to ferric ions. In particular the speciation between ferrous and ferric ions is clear (fig.3). Moreover this sensor is versatile and can be adapted to a whole variety of applications in biomedicine or for the monitoring of the environment and of water distribution and treatment.

References

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Figures

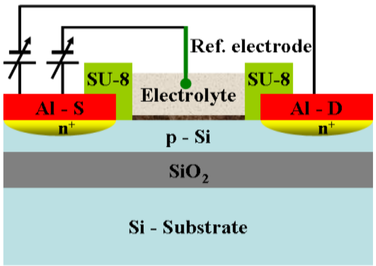

Figure 1: Schematic view of the BioFet device. A SU-8 resist is used to get the electrical insulation between drain, source and gate

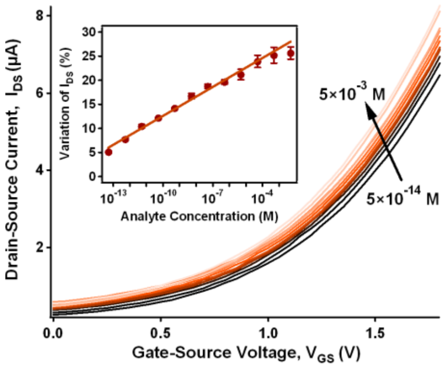

Figure 2: Transfer characteristic of the BioFet sensor versus ferric ion concentration in the analyte. The insert gives the variation of the IDS current versus ferric concentration

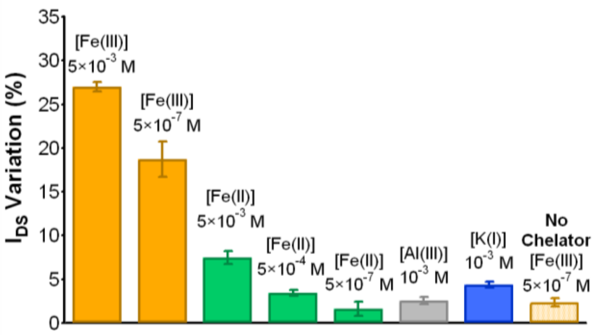

Figure 3: Variation of the IDS current versus different ion concentration