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Dissolved and gaseous oxygen sensing using Organic Electrochemical Transistors (OECTs) for monitoring cell hypoxia conditions and work-safety applications

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Oxygen plays a key role in the energy-generating processes of living entities, thus being one of the most important element for life, fundamental in liquid as well as in gaseous environment. In culture media for example, dissolved oxygen level is an interesting parameter worth monitoring because in hypoxic conditions cells grow faster and live longer.[1] On the other hand, gaseous oxygen deficiency still represents a major threat for workers in confined spaces, since injuries or death caused by reduced oxygen levels are more frequent than for other hazardous gases.[2]

In this work, the electrocatalytic activity of the semiconducting polymer poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) towards oxygen was exploited to transduce the oxygen concentration into a variation of the polymer conductivity. Indeed, PEDOT:PSS switches from the less conductive neutral state to the more conductive oxidized one, upon oxygen-concentration increase, according to the following equation:

$$4Pedot^0 + O_2 + 4H^+ \rightarrow 4Pedot^+ + 2H_2O \qquad (1)$$

We used PEDOT:PSS-based Organic Electrochemical Transistors (OECTs) for O2 sensing, measuring the current variation in the channel caused by different oxygen percentage: the transistor configuration carried signal amplification, excellent sensitivities and filtering of raw signal.

Dissolved oxygen sensing was performed both in standard saline solution and in culture media, in the selected range [0-5% (v/v)] of O2. The extremely low limit of detection in the biological environment (3 µM, equivalent to an oxygen percentage of 0.25%) allows to foresee potential investigation of in-vitro cultures grown in hypoxic conditions.[3]

Oxygen gas sensing was obtained by substituting the liquid electrolyte with an agarose-based thin hydrogel film (30µm): the fast O2 solubilization in the hydrogel enabled the real-time oxygen monitoring in a concentration range that is significant for work-safety applications [13-21% (v/v)]. The low-power consumption (30 - 40 µW) and bendability (without performance loss) of the devices patterned on flexible, 125 µm thick Polyethylene napthalate (PEN) films, pave the way for a sensors that could be integrated in worker overalls as a standard protective equipment.

a)

b)

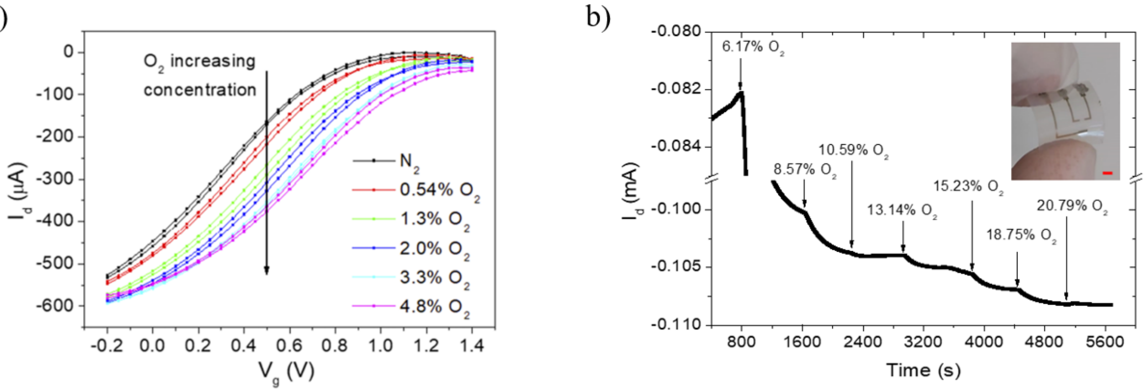

Figure 1: a) OECT transfer response upon different dissolved oxygen concentration [0-5% (v/v)] in saline solution. b) Oxygen gas sensing using a flexible, hydrogel-coated OECT in the work-safety range [13-21% (v/v)].

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References

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