Disposable potentiometric strips: a versatile tool for low-cost sensing

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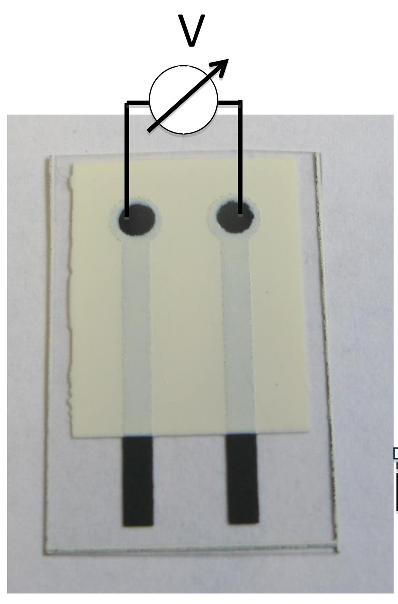
❖ INTRODUCTION

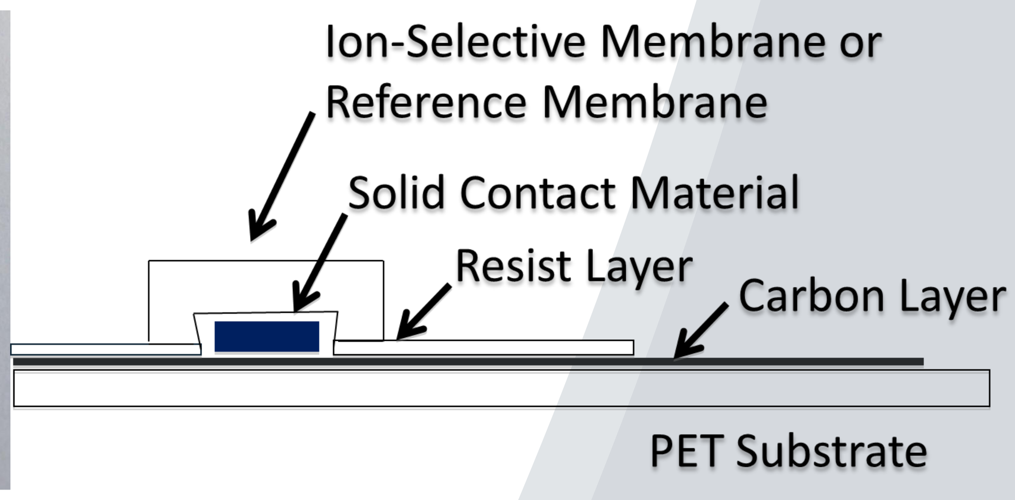
Nowadays, one of the key technological challenges is to provide low-cost, minimally invasive sensing devices in order to monitor chemicals *in situ* and *real-time,* in the environment and human body[1]. For instance, the detection of toxic metals in the biosphere is fundamental for providing better epidemiologic studies[2]. In addition, the easy access to body fluids such as saliva and sweat offer interesting applications to wearable sensors suitable in health care[3] and sport science[4].

We report on the preparation of disposable potentiometric strips suitable to monitor lead, sodium in sweat and pH within the mouth. We also present the progress related to the miniaturized electronic platforms able to plug these strips and transmit data wirelessly.

❖ SENSOR PREPARATION

Dual-electrodes are prepared by screen printing in order to reduce cost[5]. An appropriate solid contact material is interposed between the carbon layer and the ion-selective or reference membrane, drop-cast onto one of the modified electrodes. The ion-selective membrane is sensitive to a particular ion through the ionophore while the reference membrane is insensitive to most ions. By measuring the potential bias between the two electrodes, the concentration of the primary ion in solution can be inferred.





❖ LEAD AS AN EXAMPLE FOR ENVIRONMENTAL APPLICATIONS

According to the Environmental Protection Agency regulations, the levels of lead into the water should not be above 15 ppb[6], due to its well-known adverse impact on people's health and well-being[2]. Figure 1 shows the calibration curve of four sensors with an average limit of detection corresponding to 10.4±0.6 ppb (n=4). As these sensors are inherently solid-state and compatible with high volume production techniques, the unit cost will be very low, of the order of cents.

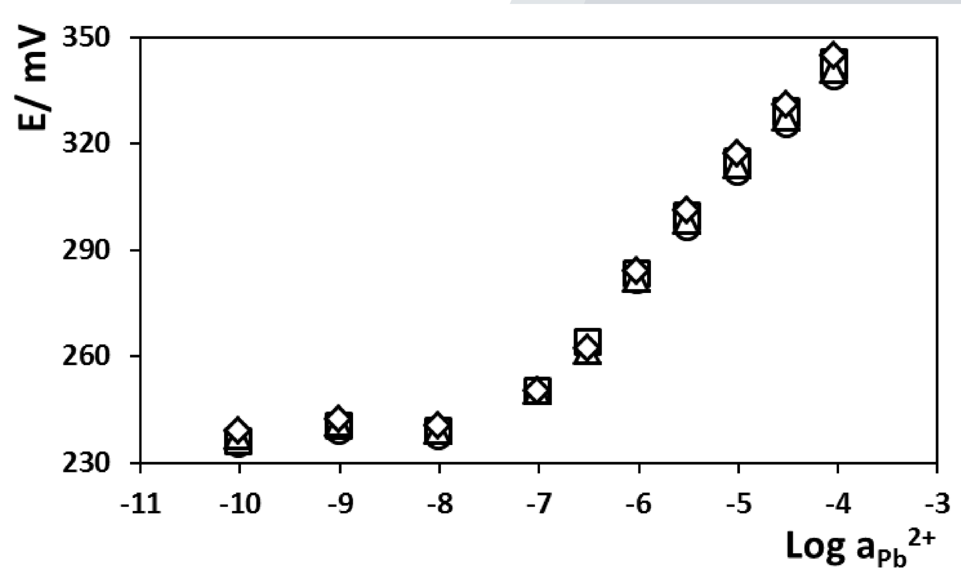
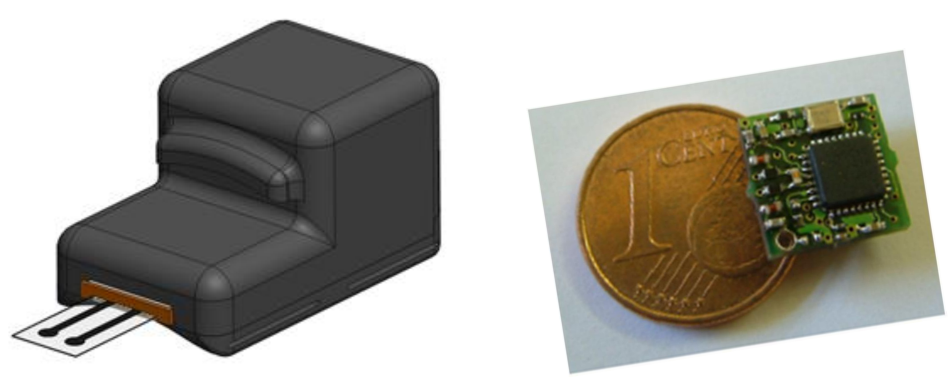


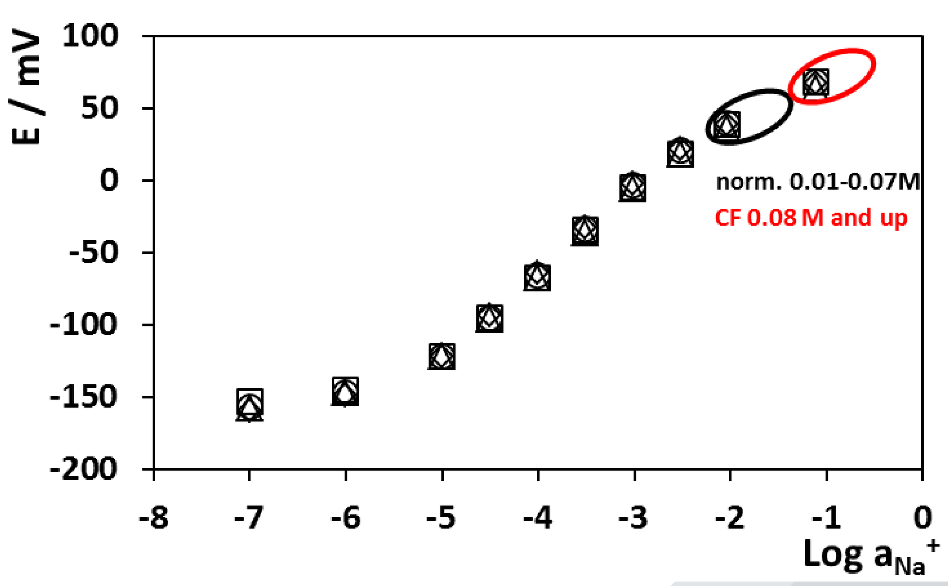
Figure 1: Calibration of *Pb^{2+} Sensors*

❖ SODIUM MONITORING IN SWEAT

Figure 2a displays the miniaturized wearable potentiometric platform developed to monitor sodium levels in sweat. Figure 2b shows the calibration curve of four sensors, able to monitor sodium activity in the range 10^{-5}-10^{-1}. The table reports Na^+ levels in three sweat samples, values obtained through extrapolation from potentiometric measurements and Atomic Absorption Spectroscopy (AAS) analyses.



(a)



(b)

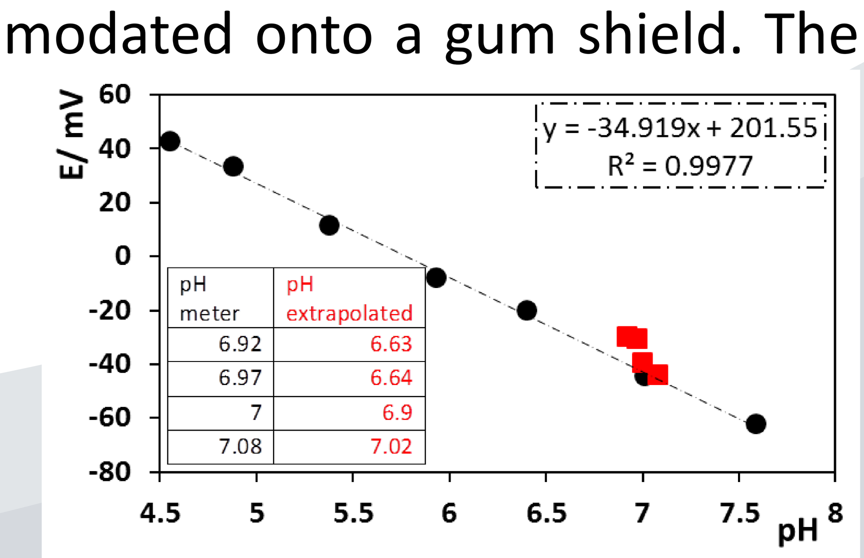
SAMPLE	AAS values (M)	ISEs values (M)
1	35.0×10^{-3}	37.1×10^{-3}
2	27.8×10^{-3}	30.2×10^{-3}
3	31.8×10^{-3}	34.4×10^{-3}

(c)

Figure 2: **(a) Wearable device** together with the sensor plugged into a custom-built connector. **(b)** Calibration of Na^+ sensors: the black circle points out the normal range for Na^+ in sweat, while the red circle indicates the typical range for people affected by Cystic Fibrosis. **(c)** Table showing good agreement in the estimation of Na^+ concentration of three sweat samples obtained with AAS and the ISEs.

❖ pH DETECTION IN SALIVA

Figure 3(a) illustrates the calibration curve of a pH sensor and 4 **real saliva samples** measured with the same sensor. The inset table compares the pH of saliva samples measured with a standard pH meter to those otained with screen printed ISEs. Figure 3(b) shows the Wixel® USB wireless module, easily accommodated onto a gum shield. The integration of the pH-sensor in the gum shield opens the way to real-time in-mouth pH monitoring in saliva.



(a)

(b)

Figure 3: (a) Calibration of the pH-sensor (black dots) and analysis of real-saliva samples (red dots). **(b)** Miniaturized electronic circuit based on the Wixel® USB wireless module, integrated into a gum shield.

❖ REFERENCES

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❖ ACKNOWLEDGMENTS

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