New Materials for Disposable Sensors

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Nanocellulose derived from cellulose nanofibers is a material derived from wood and is the most common natural polymer. Because nanocellulose is transparent, light and strong, it can be used in place of plastic or glass, it is completely renewable and can be used in various industrial applications. Here, we investigate the use of this novel material as a substrate for printed electrodes.

Upcoming sustainable future technologies rely on the development of new materials. They must meet the technological requirement of showing physical and mechanical characteristics similar to or enhanced with respect to the materials currently in use. Another important aspect to be taken into account is that at the end of the life cycle, these products should be able to be reused, recycled or disposed in an environmental-friendly and sustainable way.

Flexible printed electronics are important because of their low cost, large scale, roll-to-roll manufacturing capability. The substrate is one major component – and the major waste – of the electronic device and its properties will determine if the device will be flexible or rigid, heavy or light, transparent or opaque. Regular paper and plastic are two commonly used flexible substrates for printed electronics; paper based on nano-structured material is an emerging sustainable, transparent and flexible substrate with excellent physical and chemical characteristics.

CSEM has tested nanocellulose as a substrate to print flexible electrodes, in order to create a renewable, flexible, cost-effective screen printed electrodes (SPEs) (Figure 1).

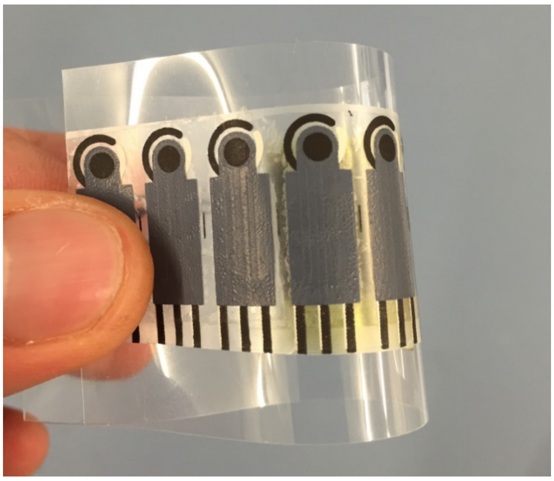

Figure 1: Screen printed electrodes printed on nanocellulose.

The first study focused on the evaluation of the electrochemical quality of the electrodes printed on nanocellulose. In this regard, the electrochemical behavior using ferro/ferricyanide (a reversible system) as an electrochemical probe was investigated with SPEs printed using cyclic voltammetry as a diagnostic technique. As shown in Figure 2, the peaks of the redox system of ferro/ferricyanide are clearly visible on the scans, and show good reversible behavior, as expected for measurement with a good quality sensor material.

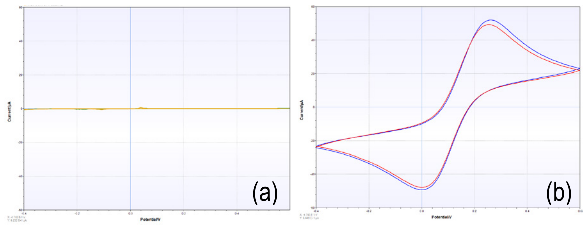

Figure 2: Cyclic voltammetry plots recorded using two different SPEs printed on nanocellulose. In KCl 0.1 M (a) in absence and (b) in presence of ferro/ferricyanide 5 mM, scan rate=50 mV/sec.

When the sensors are functionalized with an oxidase enzyme to produce, for example, glucose sensors, the active redox species used to quantify glucose is hydrogen peroxide (H_2O_2). In order to prove the full functionality of the printed sensors for this aim, we functionalized the sensors for the specific detection of H_2O_2, and tested the response of the sensors in the presence and absence of H_2O_2 in buffer solution (Figure 3).

The change in the response of the sensor in the presence of H_2O_2 is clearly visible in Figure 3b, clearly different from the scans in Figure 3a. This indicates the possibility of using the sensors for quantification of H_2O_2., thus making the nanocellulose based sensors a valuable alternative for less sustainable plastic substrates.

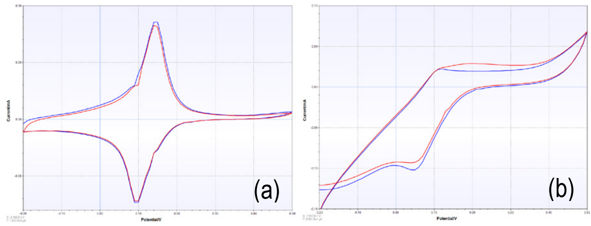

Figure 3: Cyclic voltammetry in PBS 0.05 M+ KCl 0.1 M, pH=7.4 (a) in absence and (b) in presence of H_2O_2 10 mM, scan rate=50 mV/s.