Decorated Carbon Nanostructured Electrodes for Biofuel Cell applications

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One-compartment biofuel cells are considered as an attractive power sources and they are in high demand for small biomimetic-based medical devices [1].

This kind of cells (Fig. 1) needs very active and tolerant catalysts which are highly-important for mixed-reactant system applications. Therefore, Buckypapers (BPs) were fabricated from commercially available carbon nanotubes (CNTs) (Fig. 2a) and decorated with redox enzymes (Fig. 2b) [1-4]. BP is mesoporous, highly conductive, flexible and mechanically stable material [2]. A high enzyme molecules loading on BP can be achieved due to its large mesoporous surface area which enhances also the utilization and electroactive surface area (i.e. coverage effect).

The enzymatic cathodes based on bilirubin oxidase or laccase [4] decorated-BP electrodes showed significant enhancements of bioelectrocatalytic performance with direct electron transfer for molecular dioxygen reduction reaction [3,4].

Using such three-dimensional electrodes based on BP or redox hydrogel matrix can solve the problems associated with the use of traditional two-dimensional electrodes. The performance of the cells was studied depending on the operation conditions. The highest power output of 26 µW cm-2 at + 0.20 V was achieved in O2-saturated solution (pH 7.2 at 37 °C) with a physiological glucose concentration of 5 mM. Moreover, in contrast to the literature, our bioelectrochemical system seems to be more effective and reproducible in O2-saturated phosphate buffer solution than air [5].

Furthermore in this contribution, our progress on synthesizing novel carbon nanostructures by inductively coupled radio frequency (RF) plasma enhanced chemical vapour deposition (PECVD) will be presented as well. The resulting vertically-aligned carbon nanostructures (CNs) of 2D carbon nanowalls (Fig. 3a) and 1D nanofibers (Fig. 3b) can be controlled and grown on different surfaces. These nanostructures can accelerate the bioelectrocatalytic reactions by facilitating the mass transport and thus the rapid diffusional fluxes of reactants and products to internal surfaces.

References

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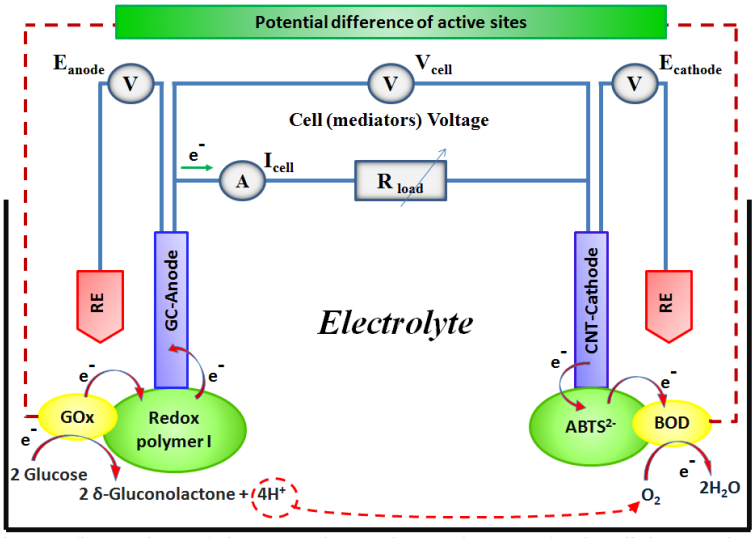

Figure 1: Schematic configuration of the membraneless glucose fuel cell (DGFC), employing glucose and oxygen as a fuel and an oxidizer, respectively. RE represents reference electrode.

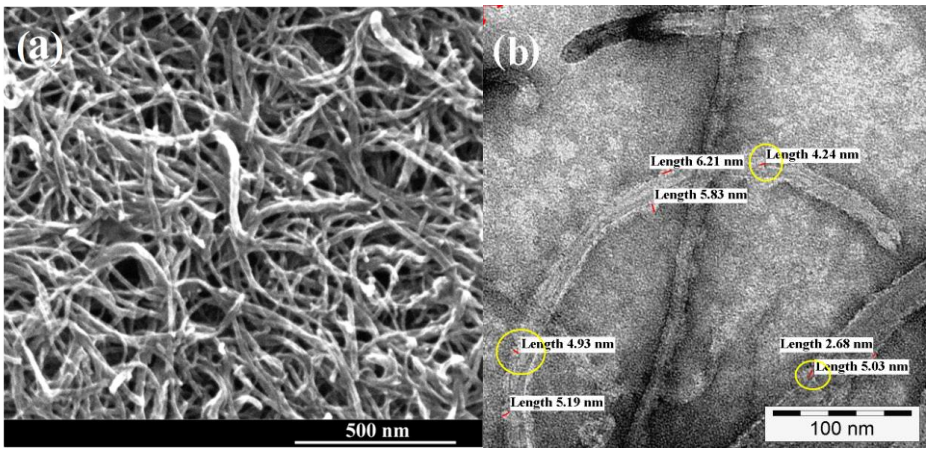

Figure 2: SEM a) and TEM b) images of the laccase decorated-BP electrode.

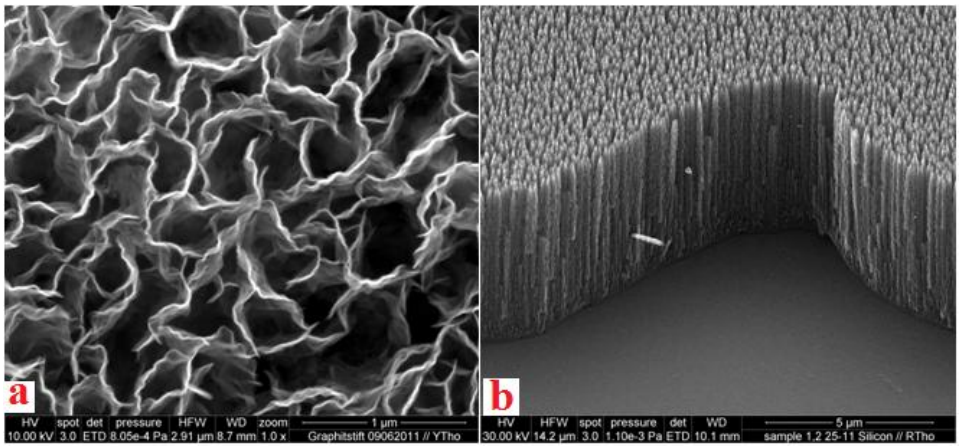

Figure 3: SEM images of different vertically-aligned carbon nanostructures: (a) carbon nanowalls, (b) carbon nanofibers.