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Nanostructured carbon bio-cathodes for enzymatic biofuel cells with direct electron transfer

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Among the new sources of renewable and sustainable energy under development, biofuel cells which convert chemical energy into electrical energy using enzymes as catalysts show a clear acceleration of research for 10 years(i). However, several challenges have still to be faced before such devices can get close to become a commercial reality, including the increase of the power output for more demanding electronic devices. Two main parameters of the biofuel cell design are crucial t: the overall available surface for enzyme immobilization and the wiring of the biocatalyst on the electrode in order to optimize the transfer between the electrode and the active site of the enzyme(ii). Carbon nanotubes deposited on graphite and graphene have been extensively investigated in the field(iii). We propose an alternative and innovative method leading to a considerable increase of the surface area of graphite: synthesis of carbon nanowalls (CNWs) described as self-assembled, vertically standing, few-layered graphene sheet nanostructures(iv) by plasma-enhanced chemical vapor deposition in a CO/H2 microwave discharge. CNWs were then functionalized by atmospheric plasma to ensure efficient enzyme grafting. Design of experiments methods have been performed to optimize the plasma functionalization parameters as well as the immobilization conditions of laccase. The controlled immobilization of laccase on the surface of the electrode involving its amine or aldehyde groups (after oxidation of the glycoside groups) made it possible to reach currents greater than 1 mA/cm2, which makes this approach competitive by compared to the best performances achieved to date. (i) 1. M. Rasmussen et al Biosens. Bioelectron. (2016), 76, 91-102, (ii) S Cosnier et al J Power Sources, (2016), 325, 252-263, (iii) AA Babadi et al, Biosens Bioelectron, (2016), 79, 850-860,(iv) S. Mori et al, Diamond Relat. Mater., (2011), 20, 1129.

Keywords
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