Biosensors & Bioelectronics-2013

OMICS Group Conferences
Accelerating Scientific Discovery

2nd International Conference and Exhibition on
Biosensors & Bioelectronics

June 17-19, 2013 Hilton Chicago/Northbrook, USA

Cost-effective bionanocomposites as a route to scale-up construction of enzymatic biofuel cells

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Abstract

In biofuel cells (BFCs), immobilized biocatalysts, i.e. enzymes or whole microbial cells are used for oxidation of a substrate on an anode surface and for a coupled reduction of a depolarizator on a cathode surface in order to harness an electrical energy from a given biofuel. The amount of a biocatalyst and thus a power output of BFCs can be substantially increased using nanostructured electrode interfaces. For that purpose, among others, carbon black dispersed in highly hydrophobic fluorinated polymers (PTFE or PVDF) were used successfully.

In our work, expensive fluorinated polymers were replaced by a renewable polysaccharide chitosan which was used as a dispersing agent for KetjenBlack (KB) nanoparticles together with carbon nanotubes (CNTs). Combination of these nanomaterials allowed a construction of an electrode nanointerface suitable for an effective adsorption of fructose dehydrogenase as an anodic biocatalyst and bilirubin oxidase (BOD) as a dioxygen reducing cathode biocatalyst in a manner that allowed a direct electron transfer of both enzymes (no additional mediators were needed). Furthermore, chitosan offered a proper orientation of BOD and increased proton conductivity of the interface.

Such prepared bioanode and biocathode were characterized using cycling voltammetry and consequently used for a construction of a membrane-less fructose/O_2 BFC. The device possessed an open circuit voltage of 655 mV and a power output of 50 □W cm^{-2} under mild conditions. Availability and a low cost of used materials and efficiency of biocatalysts immobilization on KB-CNT/CHI nanointerface are very promising for construction of high-area and cheap electrodes for biofuel cells.

Biography

Jaroslav Filip received his MSc degree in environmental engineering at Tomas Bata University (Zlín, Czech Republic) in 2009 with diploma thesis aimed to a biodegradation of biopolymer blends. Currently, he is completing his PhD study in biotechnology with focus on the application of nanomaterials in biofuel cells construction at Slovak Academy of Sciences, Institute of Chemistry (Bratislava, Slovakia). He authored 7 CC publications, 8 conference contributions with 7 citations so far. His current research field covers effective employment of different nanomaterials and biocatalysts – enzymes and microbial fuel cells – for a construction of biosensors and biofuel cells.