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An integration of nanomaterials with biocatalysts as a way to gain power of biofuel cells

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Biofuel cells (BFCs) have recently emerged as a sustainable and biocompatible alternative to conventional, inorganic compounds-based low power resources. Either purified enzymes or bacterial cells are employed in BFCs for conversion of inexpensive substances into electricity which is typically achieved by immobilization of the biocatalysts on electrode surfaces. By integration of biocatalysts with diverse types of nanoparticles operational features of BFCs could be boosted due to a higher amount of biocatalytic units immobilized and due to enhanced electron conductivity.

Following the aforementioned principles, we have developed a protocol for immobilization of bilirubin oxidase – an enzyme catalyzing very efficient reduction of oxygen, hence a promising biocatalyst for cathodes of BFCs. The enzyme was adsorbed on surfaces coated with carbon black dispersed in biopolymers, i.e. chitosan and poly(lactic acid). The former was helpful for unveiling some features of the enzymatic catalysis and electron transfer mechanism (Filip et al., Electrochim. Acta 87 (2013) 366) while the latter was shown to be more interesting material for fabrication of scaled up electrodes of a membraneless, one compartment fructose-oxygen BFC (Filip et al., Int. J. Electrochem. Sci. 9 (2014) 2491). Furthermore, we have recently developed an efficient technique for integration of bilirubin oxidase with graphene sheets (Filip et al., Electrochem. Commun. 49 (2014) 70). This nanomaterial was also used for immobilization of *Gluconobacter oxydans* cells which are known to have extremely efficient enzymatic cascades located in cytoplasmic membrane and thus very suitable for fabrication of BFC anodes. Similarly, other nanomaterials including carbon nanotubes and very cheap carbon blacks were shown to be readily integrated with *G. oxydans* cells with a correlation between nanoparticle shapes and efficiency of the electricity harvesting having been found (Šefčovičová et al., Chemical Papers 69 (2015) 176).

It can be concluded that inexpensive carbonaceous nanomaterials like graphene derivatives or carbon black represent one of very promising paths for further development of sustainable and environmentally clean resources powering for example small personal electronic devices.

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