DEVELOPMENT OF THE GLUCOSE BIOFUEL CELL BASED ON GLUCOSE OXIDASE MODIFIED ANODE AND CATHODE

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Fuel cells are electrochemical devices that can generate electrical energy using noble metal catalysts. Much cheaper and environmentally friendly energy generating devices are enzymatic biofuel cells (EBFC) which are capable of directly transforming chemical energy from redox enzymes to electrical energy via electrochemical reactions [1]. One of the most promising and widely studied EBFC is glucose biofuel cell (GBFC). GBFC consists of two components: bioanode, which is modified with glucose recognizing enzymes, such as glucose oxidase (GOx), and a biocathode, where reduction of oxidants such as O_2 or H_2O_2 takes place [2]. Despite the great effort of scientists, there are no GBFCs efficient enough for practical use, so, the biofuel cells where both anode and cathode are modified by the same enzyme in order to increase fuel cell performance rapidly gain more and more attention [3]. In this work, GBFC with both anode and cathode modified GOx electrodes was constructed and the operation was investigated.

Anode was constructed by three modification steps. First of all, 10- phenanthroline-5,6-dione (PD) was absorbed on the surface of the graphite rod (GR). Then the polymeric layers of poly-PD and poly(pyrrole-2-carboxylic acid) (PPCA) with encapsulated gold nanoparticles were formed by cyclic voltammetry (CV). Finally, the carboxylic groups, which occur in the PPCA layer, were activated by the mixture of NHS/EDC solutions and the GOx enzyme was covalently linked to the surface of the anode. This way, the modified anode could catalyze glucose oxidation and generate electrons using glucose as the main fuel source [4].

Similarly to the anode, the cathode was also prepared by three modification steps. Firstly, Prussian blue (PB) nanoparticles were synthesized in PPCA polymeric shell by CV. Then, the second layer of PPCA was deposited on the top of the first layer also by CV. Finally, GOx was covalently linked with the carboxyl groups of the PPCA layer. PB on the cathode surface could reduce H_2O_2, which occurs during the enzymatic glucose oxidation reaction, and immobilized GOx enzyme on the cathode surface increases performance of the fuel cell.

Using previously described anode and cathode electrodes a low-cost and high-efficiency GBFC was constructed and the performance of this biofuel cell was investigated. Also, the impact of glucose concentration and pH on the biofuel cell was studied. The obtained data indicates that this simple design biofuel cell can generate electricity using glucose as the main fuel source.

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References

1. D. Leech, P. Kavanagh. Enzymatic fuel cells: Recent progress. Electrochima Acta. 84 (2012) 223–234.
2. G. Slaughter. Enzymatic Glucose Biofuel Cell and its Application. Biochips & Tissue Chips. 05 (2015).
3. A. Koushanpour, M. Gamella. A Biofuel Cell Based on Biocatalytic Reactions of Glucose on Both Anode and Cathode Electrodes. Electroanalysis. 29 (2017) 950–954.
4. A. Kausaite-Minkstimiene, L. Glumbokaite. Reagent-less amperometric glucose biosensor based on nanobiocomposite consisting of poly(1,10-phenanthroline-5,6-dione), poly(pyrrole-2-carboxylic acid), gold nanoparticles and glucose oxidase. Microchemal Journal. 154 (2020) 104665.