DISSERTATION ABSTRACT

Biosensor platforms based on modified electrode materials are designed to quickly and non-invasively detect analytes and bioanalytes from solutions and body fluids. Therefore, to ensure a stable platform, biosensors based on nanomaterials deposited on the surface of electrodes are designed.

The subject of the doctoral dissertation was to develop a method and assess the degree of modification of selected electrodes and nanomaterials, which were the basis of the biosensor platform for electrochemical detection of bioanalytes: propathogenic strains of Escherichia coli bacteria (UPEC-57) and the hormone human chorionic gonadotropin (hCG). The electrode materials selected as the subject of the research were GC, ITO, Au and CB-PLA, while the basis of the electrochemical biosensor were gold nanocubes. The selection of AuNCs was determined their ability to self-organize on the electrode surface and the possibility of further modification. In the first step, the GC, ITO, Au electrode materials were thoroughly electrochemically characterized before and after the modification process using AuNCs. The effect of the CTAB surfactant on the process of electrode reactions was also checked. It was proven that the best material for further research is the GC electrode, but the surfactant must be carefully removed because it inhibit the further modification steps. In the next stage of research, the GC electrode surface modification process was optimized and carried out using AuNCs, selected DNA strand sequences and RNA polymerase. Also, its effectiveness was checked using electrochemical methods: CV, EIS and DEIS. The results of the conducted studies proved the possibility of detecting UPEC-57 at a very low concentration level and in a short time. Subsequently, the gold electrode was modified using a synthetic peptide specifically interacting with the hCG hormone. It was proven that this hormone can be detected at a very low concentration level in both physiological saline solutions and human serum. Moreover, the use of CB-PLA was proposed as an alternative to commercial electrodes. However in the first stage it was necessary to develop and compare the method of activation of new CB-PLA electrodes obtained by 3D printing by electrochemical activation and enzymatic etching. It was shown that the proposed method of electrode activation in an alkaline solution significantly improved the rate of the electrode reaction and increased the electrochemically active surface. Enzymatic etching also led to the activation of the electrode surface to a comparable extent as in the case of electrochemical activation in an alkaline solution.

In the last stage, the results of the research on the modification of CB-PLA electrodes using AuNCs and anty-hCG antibodies to detect the hCG hormone were presented. The effectiveness of the above biosensor platform was tested in physiological saline solution and human serum. The experimental results proved that the proposed biosensor detects the hormone at a very low level, while the use of AuNCs significantly affected the reproducibility and repeatability of the measurement results conducted in human serum.