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Protein-Modified-Paramagnetic-Particles as a Tool for Detection of Silver(I) Ions

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In a number of published articles the toxic effect of silver(I) ions on aquatic organisms is described. Silver(I) ions in aquatic environment are stable in a wide range of pH. Under alkali pH AgOH and Ag(OH)2- can be formed. However, in water environment there are many compounds to interact with silver(I) ions. The most important ones are chloride anions, which forms insoluble precipitate with silver(I) ions (AgCl). The insoluble silver containing compounds do not pose any threat to aquatic organisms. Toxicity of silver ions is probably caused by their very good affinity to nucleic acids and also proteins. The binding into active enzyme site leads to the expressive enzyme reaction inhibition. Silver(I) ions are into living environment introduced thanks to anthropogenic activities. They easily contaminate atmosphere as well as aquatic environment or soils. Several authors described using of carbon electrode as working electrode for determination of silver.

Recently, we have suggested heavy metal biosensor based on interaction of metal ions with low molecular mass protein called metallothionein (MT), which was adsorbed on the surface of hanging mercury drop electrode (HMDE). The biosensor was successfully used for detection of cadmium(II) and zinc(II) ions, cisplatin, cisplatin-DNA adducts and palladium(II) ions. Due to the convincing results with MT as biological component we report on suggesting of heavy metal biosensor based on immobilization of metallothionein (MT) on the surface of carbon paste electrode (CPE) via MT-antibodies. Primarily we studied of basic electrochemical behaviour of MT at surface of carbon paste electrode by using of square wave voltammetry (SWV). Detection limit (3 S/N) for MT was evaluated as 0.1 μg/ml. After that we have evaluated the electroactivity of MT at surface of SWV, we aimed our attention on the way of capturing of MT on the surface of CPE. We choose antibody against MT obtained from chicken eggs for these purposes. Antibodies incorporated mixed with carbon paste were stable. Even after 14 days we did not determine change in the peak height higher than 5 %. Further linkage of MT with polyclonal chicken antibodies incorporated in carbon paste electrode was determined by SWV. Two signals were observed in voltammograms, cysMT corresponding to –SH moieties of MT and Wa corresponding to tryptophan residues of chicken antibodies. We optimized time of interaction (300 s) and concentration of MT (125 μg/ml) to suggest silver(I) ions biosensor. Biosensor (MT-antibody-modified CPE) prepared under the optimized conditions was utilized for silver(I) ions detection. The detection limit (3 S/N) for silver(I) ions were estimated as 100 nM. The proposed biosensor was tested by detection of silver(I) ions spiked in various water samples (from very pure distilled water to rainwater). Recoveries varied from 74 to 104 %.

MT, low molecular mass proteins rich cysteine, play important role in the processes of heavy metals ions metabolism. Due to their unique physico-chemical properties they are able to bind heavy metals with high affinity. We used this feature to suggest simple biosensor based on immobilization of MT on the surface of carbon paste electrode via chicken antibodies against MT. The suggested biosensor was further successfully employed to detect silver(I) ions. The main advantage of the biosensor is that it can be easily miniaturized, whereas carbon nanostructures with immobilized MT should be used as working electrodes.

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