USE OF SEMICONDUCTOR NANOMATERIALS FOR POLYCYCLIC AROMATIC HYDROCARBONS DETECTION IN WATER OBJECTS

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Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental agents commonly believed to contribute significantly to human cancer pathologies. PAHs are formed in the process of incomplete combustion of different organic materials and are found widely in the environment plants, food products so human exposure by PAHs is unavoidable. Like many other carcinogens, PAHs are metabolized enzymatically to various metabolites, of which some are highly reaction active. One of the most dangerous organic carcinogens is benzo[a]pyrene (BP).

There are known methods for PAHs detection in liquid solutions objects, such as chromatography, chemical, immuno-chemical, biological. However, they have a number of disadvantages like high cost, duration and complexity of the analysis procedure, high detection limit, low selectivity and some others. So, at present a development of new method of PAHs detection based on modern nanotechnologies and nanomaterials is a rather relevant and important task.

Semiconductor nanoparticles, or quantum dots (QDs), have unique photophysical properties, such as size-controlled fluorescence; high fluorescence quantum yields, stability against photobleaching and others. These properties enable the use of QDs as optical labels for the organic carcinogens detection such as polycyclic aromatic hydrocarbons. QD is a detector which reacts with the analyte such as PAHs emits an analytical optical signal. But for high efficiency of the reaction with the analyte it is necessary to choose the right size of QDs. For correct selection one ought to carry out quantum-chemical calculations of the analyte energy spectrum.

This paper considers a novel method of PAHs in particular BP detection in water solutions with the use of semiconductor nanomaterials. The method constitutes a combination of electrochemical (EC) and electrochemiluminescent (ECL) analysis [1] with the application of nanomaterials (semiconductor QDs) and nanotechnologies for sensor's electrodes modification.

The proposed analytical method is based on process of QDs transfer to ionic forms in an EC process and their subsequent reactions with oppositely charged ionic forms of the analyte – PAHs (BP) inside sensor, resulting in the formation of the emitter and emission of the analytical optical signal. The number of quanta emitted at the given period of time is a measure of PAHs (BP) content thus characterizing the essence of nanophotonic method of quantified PAHs (BP) detection in water. Increase of the selectivity of the proposed method is caused by the peculiarities of EC method, that consists in formation of charge reactants while using one of known methods of EC analysis, physical one based on the selection of specific QDs for the analyte detection by finding and calculation of the optimal physical parameters (nature, content and size) of QDs and mechanical one that include probe preparation and filtration.

Reactants are electrochemically oxidized and reduced, correspondingly, in nanophotonic sensor fabricated from at least two parallel electrodes situated in a thin-layer cell. During electric current flow through sensor's electrodes electron-transfer reactions between electrode and corresponding particles – analyte (PAHs) or QDs are taking place. The working electrode constitutes specially prepared optically transparent semiconductor ITO plate modified by thin-layer ordered film of QDs' plotted by Langmuir-Blodgett or spin-coating methods [2]. This improves sensor's response for detection of a very low, trace including analyte amounts. Data of experiment testing of the proposed method and sensor's instrument for BP detection are being provided and discussed.

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