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The Solid-Phase Sensor Systems for Fluorescent and SERS-Recognition of Neurotransmitters for Their Visualization and Determination in Biomaterials

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Abstract : Such catecholamines as dopamine, norepinephrine, and epinephrine are the principal neurotransmitters in the sympathetic nervous system. Catecholamines and their metabolites are considered to be important markers of socially significant diseases such as atherosclerosis, diabetes, coronary heart disease, carcinogenesis, Alzheimer's and Parkinson's diseases. Currently, neurotransmitters can be studied via electrochemical and chromatographic techniques that allow their characterizing and quantification, although these techniques can only provide crude spatial information. Besides, the difficulty of catecholamine determination in biological materials is associated with their low normal concentrations (~ 1 nM) in biomaterials, which may become even one more order lower because of some disorders. In addition, in blood they are rapidly oxidized by monoaminooxidases from thrombocytes and, for this reason, the determination of neurotransmitter metabolism indicators in an organism should be very rapid (15—30 min), especially in critical states. Unfortunately, modern instrumental analysis does not offer a complex solution of this problem: despite its high sensitivity and selectivity, HPLC-MS cannot provide sufficiently rapid analysis, while enzymatic biosensors and immunoassays for the determination of the considered analytes lack sufficient sensitivity and reproducibility. Fluorescent and SERS-sensors remain a compelling technology for approaching the general problem of selective neurotransmitter detection. In recent years, a number of catecholamine sensors have been reported including RNA aptamers, fluorescent ribonucleopeptide (RNP) complexes, and boronic acid based synthetic receptors and the sensor operated in a turn-off mode. In this work we present the fluorescent and SERS turn-on sensor systems based on the bio- or chemorecognizing nanostructured films {chitosan/collagen-Tb/Eu/Cu-nanoparticles-indicator reagents} that provide the selective recognition, visualization, and sensing of the above mentioned catecholamines on the level of nanomolar concentrations in biomaterials (cell cultures, tissue etc.). We have (1) developed optically transparent porous films and gels of chitosan/collagen; (2) ensured functionalization of the surface by molecules-'recognizers' (by impregnation and immobilization of components of the indicator systems: biorecognizing and auxiliary reagents); (3) performed computer simulation for theoretical prediction and interpretation of some properties of the developed materials and obtained analytical signals in biomaterials. We are grateful for the financial support of this research from Russian Foundation for Basic Research (grants no. 15-03-05064 a, and 15-29-01330 ofi_m).

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