ONE-MOLECULE SHOW: NOVEL APPLICATIONS OF METHYLENE BLUE DYE IN PHARMACOLOGY AND NANOBIOPHYSICS

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Among a variety of stories of biologically active compounds, the one of Methylene Blue (MB) cationic redox-active dye is chosen for the present discussion due to the emergence of its new applications in pharmacology, biomedicine and nanosciences [1, 2].

Being used as antiseptic since its first preparation in 1876, nowadays MB is continuing to find novel applications. Popular in the middle of the last century use of MB as an antimalarial agent is currently revived in development of more efficient antimalarial drug compositions. One more promising pharmaceutical application of MB is connected with investigations of its potential activity in retardation of neurodegenerative Alzheimer's disease. Photophysical properties of MB are utilized in photodynamic therapy of cancer. In molecular biophysics research MB is used in investigations on interactions of intercalating agents with DNA.

MB applications in nanotechnology are based on its fluorescence, redox and aggregation properties [3]. Ability of MB to "shuttle" electrons provides its use as a mediator component in biosensors. In a new generation of electrochemical amperometric biosensors hybrids of MB and DNA are applied [4]. The principle of functioning of such nanodevices is as follows. DNA is attached to the surface of the sensor electrode by one end, and MB is tethered to its other end. The change of the DNA conformation in response to the target molecule recognition event changes the distance of the tethered MB to the electrode surface and correspondingly the efficiency of electron transfer (electric current) from the MB. Basing on this principle genosensors for detection of DNA hybridization, DNA damage, genetically modified organisms, oncomarkers, viruses, and *on-line* monitoring of polymerase chain reactions are developed.

Molecular mechanisms of action of MB and its redox transformations in various systems can be modeled and studied by means of mass spectrometric techniques [3]. In particular, mass spectrometric experiments permitted to reveal relationships between the monomer/dimer equilibrium and redox activity of MB [5]. Self-assembly and properties of composites incorporating MB and carbon nanomaterials [6], such as carbon nanotubes, graphene and fullerenes are disclosed.

In conclusion, this brief overview demonstrates how versatile physical and chemical properties of MB dye assure its diversified applications in pharmacology and nanotechnology.

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