Study of energy transfer processes in flavin mononucleotide – xanthene dye complex

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The phenomenon of electron excitation energy transfer is widely used in physical-chemical and molecular-biological studies of structure and conformational dynamic of macromolecules. The processes of intermolecular energy transfer with flavin mononucleotide (FMN) and its reduced form are of crucial importance in bioluminescence reaction because it performs as a dominant substrate in the formation of bioluminescence emitter. In the present paper the model compounds of xanthene dyes (eosin Y, erythrosin B) are used as energy excitation acceptors. The application of xanthene dyes as fluorescent probes proved to be quite successful in structural study of the biological molecules and vital activity processes in different complex systems. Photophysical and photochemical characteristics of these dyes are well known, therefore it is convenient to employ them as tests for studying the intermolecular interactions features and processes of electron excitation energy transfer in such complicated systems as bioluminescent. The goal of our work was to research the processes of excitation energy transfer on the example of FMN – xanthene dye model system.

In the first part of our research the absorption and emission spectra of FMN and xanthene dyes were registered. These spectral data were used to calculate the critical distance of energy transfer on the basis of Förster theory. The results of critical distance of energy transfer obtained from spectral overlap integral are 47 ± 2 Å for eosin Y and 49 ± 3 Å for erythrosin B.

In the second part of our work the emission spectra of FMN aqueous solutions in the presence of xanthene dyes of different concentrations were measured. Owing to the spectral overlap between emission of FMN and absorption of dye, the energy transfer occurs in two pathways: radiationless intermolecular channel and radiative mechanism of donor's de-excited energy absorption by acceptor. In the systems studied the quenching of FMN fluorescence quantum yield and sensitization of xanthene dyes yield were observed. Emission spectra of binary complexes were corrected for all distortion effects.On the basis of defined dependency of FMN fluorescence quantum yield quenching on the dye concentration, according to Stern-Volmer plot, the quenching sphere radius for FMN-dye system was calculated: 71 ± 5 Å for eosin Y and 73 ± 6 Å for erythrosin B. The quenching sphere radius acquired proved to be almost twice greater in value then those calculated on the basis of spectral overlap integral.

So, within the bounds of this work we succeeded to record the radiationless intermolecular energy transfer between FMN and xanthene dyes and to calculate the parameters of this transfer. The critical Förster distance of energy transfer and radius of quenching sphere show that the energy transfer in FMN – dye complexes occurs according to Coulombic resonance mechanism for dipole-dipole interaction of donor and acceptor. It also should be noted that within error limits no difference in dyes response were found: the characteristics of energy transfer for eosin Y and erythrosin B can be considered identical.