

Semiconductor Nanocrystals-Sulfonated Phthalocyanines Complexes: Effect of Molecular Aggregation on Photophysical Properties

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Extended Abstract

Development of new nanomaterials and systems that can enhance the functionality of organic molecules traditionally used in biomedicine as drugs is one of the most important tasks of modern physics of nanostructures (Aguilar 2012).

Photodynamic therapy (PDT) is a promising and sensitive method of cancer treatment, which is based on the ability of photosensitizer molecules to selectively accumulate in tumour tissues and transfer photoexcitation energy to surrounding oxygen molecules (Dougherty, Gomer et al. 1998). Because of this energy transfer extremely active oxygen species that destroy cancer cells are generated. Various nanomaterials were investigated as photoexcitation energy donors and potential delivery agents for photosensitizers molecules used in photodynamic therapy. Semiconductor quantum dots (QDs) are very promising for such applications because of the unique optical and chemical properties. The major concept of QD-photosensitizer conjugated systems is to use QDs as energy donors, hereby providing “indirect excitation” of photosensitizers molecules through Förster resonance energy transfer (FRET).

For practical application of QD-photosensitizers complexes there is a need to the retention of the photophysical properties of photosensitizer molecules in complexes with QDs. To date, several studies have demonstrated that binding of the photosensitizer molecules with QDs gives rise to inception of the new radiationless channels that are competitive with FRET and can lead to deterioration in the photophysical properties of the molecules (Martynenko, Orlova et al. 2013). These phenomena is more pronounced in complexes with relatively large number of molecules per one QD and can significantly reduce the functionality of the complexes. Understanding of possible pathways of photoexcitation energy dissipation is extremely important not only for understanding the physics of intracomplex energy transfer but also for optimization of QD-molecules systems for the PDT application.

In this study spectral-luminescence technics were used to investigate FRET efficiency and photophysical properties of the various complexes of CdSe/ZnS quantum dots and aluminum sulfonated phthalocyanine (PcSz) in aqueous solutions. It was found that aggregation of the PcSz molecules on the quantum dot surface resulted in a marked decrease in the efficiency of the photoexcitation energy transfer from QDs to PcSz molecules. A physical model that describe dependency of the photophysical properties of the QD-Pc complexes from probability of acceptor aggregate formation was proposed.

In aqueous solutions PcSz molecules with the trivalent central atom (Al(OH)) form aggregates preferentially by formation of O-Al-O oxygen bridges or hydrogen bonds (Palewska, Sworakowski et al. 2012). It was found that formation of the complexes via coordination of central Al atom of the PcSz to the QDs surface allowed to avoid aggregation PcSz on the QD surface. As a result, high FRET efficiency was observed in these complexes.

Thus, we have demonstrated that formation of the non-luminescent phthalocyanine aggregates on the QD surface can significantly reduce the functionality of the complexes. We found that the complexing via binding the carboxyl groups on the QD surface with central Al metal atom of tetrapyrrole ring of Pc of the

complex formation allows the photophysical properties of phthalocyanine molecules used as a photosensitizer in the PDT to be preserved. We believe that these studies open a new approach in understanding of photophysics of photosensitizer molecules sensitizing with QDs for PDT application.

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