Lanthanides doped nanocrystals - synthesis, optical properties and biomedical applications

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Introducing to medicine and biology concept of optical markers in tremendous way has changed the recent status of these two important disciplines. This was mainly due to strong development in imaging techniques which recently allow us to investigate both static as well dynamic properties of living cells, their components and their interactions with external factors. One of the alternatives for recently dominating molecular markers are inorganic quantum dots. However, even if they are much better from physico-chemical point of view, from the application point of view the high risk of their toxicity and lack of multimodality makes them still limited in use.

One of the solutions of this problem are nontoxic, inorganic fluoride nanocrystals doped with lanthanide ions. These nanocrystals can be grow as colloidal dots, rhombs, cubes or rods with sizes ranging from 3 up to 100 nm (Fig. 1). They can be design as both down-shifting (Fig. 1a-e) or up-converting (Fig. 1f-j) emitters being also active in NIR spectral range. In addition, these markers can be used as multimodal markers where one probe can be detected with several imaging techniques (i.e. MR, CT and optical imaging). The main disadvantage of these markers is however their low excitation cross-section making their emission rather low what became a serious problem once coming to clinical use. Thus, to make them a serious candidates for practical use, their emission, relaxation and excitation mechanisms should be understood and optimized.

This paper will present results of our work on synthesis of high quality fluoride nanocrystals doped with lanthanide ions ($\beta$-NaGdF$_4$:Yb, Er and $\beta$-NaGdF$_4$:Eu) both in hydrophobic as well hydrophilic forms containing -OH, -COOH and -NH$_2$ surface groups. We will discuss in details their excitation, emission and kinetic properties including the ion-ion and ion-ligands interactions. Finally, we will present results of their bio-conjugation and example of their use in optical imaging for melanoma cancer cells detection.

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