

KBFI Teadusseminar

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Problems of rare-earth doped nanocrystals for molecular bioimaging

We consider energy transfer probing of the –OH fluorescence quenching acceptors in the Nd³⁺ doped crystalline nanoparticles (NPs), which are suitable for non-invasive methods for deep tumor imaging in the near IR spectral range (biological window) before cancer treatment. It is widely believed that fluorescence quenching is caused by interaction of fluorescent donors with the acceptors located on the surface of the NPs. However, e.g. the Forster radius of Nd-OH quenching in the Nd³⁺ doped laser glasses is of the order of one nanometer. This may lead only to quenching of the donors distributed within the thin surface layer of the NP.

In reality a major obstacle to high fluorescence quantum yield of the Nd³⁺ doped NPs is fluorescence quenching, including Nd-Nd self-quenching and quenching induced by vibrations of –OH molecular groups distributed in the volume of the NPs similar to laser glasses [1]. The latter are associated with structural and morphological defects inside the NPs. Though the water and –OH groups can be removed by annealing of the NPs at high temperature (> 400 °C) this leads to a loss of their dispersibility in colloidal solution. The problem is not raised properly because most of the papers are devoted to the up-conversion fluorescent NPs with the energy of emitted photons in the visible or even in UV spectral ranges. In this case the contribution of the quenching caused by –OH groups to the total relaxation rate is not so significant due to high energy of optical transitions. However, in the near IR spectral range the contribution of –OH groups induced quenching is significant, but there are only few papers, which are raising this issue.

We developed the energy transfer probing of –OH acceptors in the RE doped NPs [2, 3] and applied it to phosphate [4] and fluoride nanoparticles [5, 6] doped by Nd³⁺ ions. We found that the –OH acceptors can be associated with the nanocrystals structural defects [2, 4] or positioned in the mesopores filled with the mother solution or as molecular groups attached to the surface of mesopores [2 - 6].

During the talk the basics of energy transfer probing will be presented and the near IR fluorescence quenching and its origin will be compared in the series of Nd³⁺ doped nanocrystals suitable for bioimaging. The least quenched will be determined.

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