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Upconverting and Near-Infrared Emitting Nanoparticles: From Synthetic Strategies to Potential Applications

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Lanthanide-based nanostructures are well known for their outstanding optical properties that are based on the electronic configuration of the trivalent lanthanide ions (Ln3+), which is characterized by an incompletely filled 4f shell, located inside the complete 5s2 and 5p6 shells. This results in a shielding of valence electrons, which are therefore only weakly affected by the environment. Consequently, when doped in appropriate host materials, the influence of the host lattice on the optical transitions within the 4f configuration is small, and narrow optical absorption and emission bands as well as long lifetimes of the excited electronic states of the Ln3+ are obtained. Following a stepwise excitation with near-infrared (NIR, typically 980 nm) light, Ln3+-doped nanostructures show upconversion (ultraviolet, visible and NIR light) emission. In addition, NIR light of longer wavelengths (> 1000 nm) can be emitted under excitation with NIR light when appropriate Ln3+ dopants are chosen (e. g., Er3+ or Ho3+). Based on this, Ln3+-doped nanostructures have been suggested for a whole gamut of applications including the field of bioimaging and sensing. Fluorides, such as NaGd4, NaYF4 or LiYF4, are commonly considered as suitable host materials and their preparation via the thermal decomposition process has been widely studied. Alternatively, oxides, such as Gd2O3 or Y2O3, have been suggested as host materials for Ln3+ ions resulting in upconverting and NIR emitting nanostructures. Ln3+-doped oxides of various sizes and shapes (nanoparticles, nanorods) can for instance be obtained by precipitation or solvothermal approaches. In this presentation, various synthetic strategies leading to upconverting and NIR emitting Ln3+-doped nanostructures will be discussed, and their application of the resultant materials in optical bioimaging and nanothermometry will be presented.

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