Comparison of core-inert- and core-active shell structures of upconversion nanoparticles for bio-functional applications
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Abstract

Small, less than 20 nm NaYF₄: 20% Yb³⁺/2% Er³⁺ core-shell upconversion nanoparticles with an inert- and with an active shell coating of varying shell thicknesses, possessing reasonably small size distributions have been synthesized successfully. Except for the approximately 9 nm bare-core particles, all samples are in the more efficient hexagonal beta-phase. Small sizes of 10 nm and low excitation power densities are required for bio-functional applications, but upconversion nanoparticles of this size suffer from low upconversion emission intensities, especially when low power densities are used for excitation. In previous research, core-active shell particles of larger sizes, excited with higher power densities showed higher upconversion emission compared to core-inert shell particles and in this work a comparison is made between inert- and active shell coated core particles under the described conditions for bio-functional applications. It is concluded that for small particle sizes and low excitation power densities, the core-inert shell particles show superior upconversion emission compared to the core-active shell particles. This is ascribed to the superior protection from surface quenching offered by the inert shell compared to the active shell. Since surface quenching is considerably stronger for smaller particles due to their higher surface-to-volume ratio, it is concluded that the larger reduction of surface quenching induced by the inert shell coating increases upconversion emission to a higher degree than the inferior protection offered by the active shell and its increased pump photon absorption combined.