Upconverting Nanoparticles in Nano-biomedicine

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The field of upconversion in ion doped system can be traced back to an idea of Bloembergen in 1959. Bloembergen proposed that IR photons could be detected and counted through sequential absorption (ESA) within the levels of a given ion in a solid. Prior to the 1960s, all anti Stokes emissions, which were known to exist, involved emission energies in excess of excitation energies by only a few kT. Thus, they were linked to thermal population of energy states above excitation states by such an energy amount. Role of energy transfer in upconversion was recognized by Auzel in 1966. The period 1970-1990 was rich in the research of upconversion in single crystals, glasses and glass ceramics. The driving force was the search for new laser materials using upconversion. We witnessed the synthesis of many of the bulk materials such as $LiYF_2$, CaF_2, $NaYF_4$, $NaGdF_4$, YF_3, LaF_3, $LiSrAlF_6$, $LiCaAlF_6$, $LiSrGaF_6$, $LiLuF_4$, BaY_2F_8, $BaLuF_8$, for potential applications as laser host materials. This area of research continued to flourish, however there was a change appearing on the horizon with the development of nanomaterials. From late 1990s to early 2000 we witnessed an interest in studying upconversion in nanomaterials. Initially, oxides were synthesized and many studies were performed on their upconversion properties. Y_2O_3 was one of the materials studied initially and in time gadolinium gallium garnet, YVO_4 etc. were included to the list. The mid 2000 to today has witnessed an exponential growth in publications on fluoride based nanoparticles due to their efficient upconversion but principally for their potential applications in nano-biomedicine (bioimaging, drug delivery, nano-thermometry, photodynamic therapy and multifunctional platforms).

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