Reactive oxygen species generation from photoexcited quantum dot nanoparticles: Type I versus Type II photochemical mechanism

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Introduction: Quantum dots (QDs) are new class of fluorescent inorganic nanoparticles which have been widely used as diagnostic fluorescent probes for in vitro and preclinical in vivo studies. Their unique photophysical properties such as broad excitation and narrow emission spectrum, and resistance to photobleaching make them ideal for biological applications. In the biomedical arena, QDs are being studied both for their diagnostic and therapeutic applications, in particular the possibility of using QDs in photodynamic therapy. The potential of QDs for photoinduced formation of reactive oxygen species (ROS) through electron transfer (Type I) and energy transfer (Type II) was studied

Methods and materials: The formation of ROS in aqueous solutions was studied by measurement of 1270 nm luminescence, oxygen consumption, electron paramagnetic resonance (EPR) spin trapping and fluorescence probes. Generation of ROS by QDs in cellular environments was investigated using laser scanning confocal microscopy and cell metabolic activity assays.

Results: It was found that whereas singlet oxygen ($^1O_2$) was not produced by photoexcited QDs, superoxide anion ($O_2^{-}\cdot$) and hydroxyl radicals ($OH\cdot$) were generated by QDs, especially in the presence of a physiological concentration of electron donating agent including NADH. Using cell metabolic activity assays and various probes of ROS generation, the formation of ROS in cellular environments was demonstrated.

Conclusion: Illumination of QD-treated cells and bacteria with light did affect viability. The above results, together with those of assays in the presence of various scavengers of specific ROS, indicate that the formation of ROS by QDs mainly proceeded via electron transfer.