UPCONVERTING NANOPARTICLES AND PHOTOSENSITIZER CHLORIN E6 COMPLEX FOR CANCER THERANOSTICS

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A growing field of biomedical studies involves employing nanoparticles (NPs) for theranostics, a combination of therapy and diagnostics. Surface modifications, enabled by diverse ligands such as phospholipids (PLs), enhance functionality, due to PLs similarity to the cell membrane. Conjugating phospholipids with polyethylene glycol (PEG) acts as a shielding mechanism, extending NPs circulation lifetime. Among therapeutic methods, photodynamic therapy (PDT) requires only three components for effectiveness: light, photosensitizer (PS), and oxygen. However, the primary challenge lies in the limited deep tissue penetration of red light, impeding the advantages of PDT [1].

Rare earth-doped upconverting nanoparticles (RENPs) excel among NPs due to narrow emission peaks, notable biocompatibility, and the conversion of near-infrared light to visible or UV light. This conversion is beneficial for enhanced tissue penetration within the biological optical transparency window (600 nm to 1200 nm). Moreover, the increased converted energy serves as an energy donor for photosensitizer (PS) excitation. Among the PS used in research, Chlorin e6 (Ce6) stands out as a clinically approved PS with a high tendency to produce reactive oxygen species and exhibit anticancer potential. In this context, the complex of RENPs and Ce6 can be used for the development of multifunctional nanoplatform tailored for cancer theranostics [2].

The aim of the study was to perform $NaGdF^4:Yb^{3+},Er^{3+}@NaGdF^4:Yb^{3+},Nd^{3+}$ RENPs surface modifications with different ratios of PLs, to form PLs modified RENPs-Ce6 complexes with efficient singlet oxygen generation, and to assess surface-modified RENPs and RENPs-Ce6 accumulation in MDA-MB-231 breast cancer cells in different mediums. Spectroscopic properties, optical stability, hydrodynamic diameter, and singlet oxygen generation efficiency were determined. The obtained results revealed that PLs surface-modified RENPs retained emission peaks, remained stable in a water medium for 7 days, and exhibited hydrodynamic diameters ranging from 37 nm to 55 nm. RENPs-Ce6 complexes were formed, with the hydrodynamic diameter strongly corresponding to the presence or absence of the PEG molecule. Singlet oxygen generation results showed no effect in PLs modified RENPs, while RENPs-Ce6 complexes manifested a positive effect. However, phospholipids modification with a ratio of 2:1 excelled with the greatest outcome. Both PLs modified RENPs and RENPs-Ce6 complexes accumulated in breast cancer cells; nevertheless, the nature of accumulation was dependant on the cell culture medium.

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