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Radiofrequency and Near-Infrared Responsive Core-Shell Multifunctional Nanostructures Using Lipid Templates for Cancer Theranostics

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Abstract : With the development of nanotechnology, research in multifunctional delivery systems has a new pace and dimension. An incipient challenge is to design an all-in-one delivery system that can be used for multiple purposes, including tumor targeting therapy, radio-frequency (RF-), near-infrared (NIR-), light-, or pH-induced controlled release, photothermal therapy (PTT), photodynamic therapy (PDT), and medical diagnosis. In this regard, various inorganic nanoparticles (NPs) are known to show great potential as the 'functional components' because of their fascinating and tunable physicochemical properties and the possibility of multiple theranostic modalities from individual NPs. Magnetic, luminescent, and plasmonic properties are the three most extensively studied and, more importantly biomedically exploitable properties of inorganic NPs. Although successful attempts of combining any two of them above mentioned functionalities have been made, integrating them in one system has remained challenge. Keeping those in mind, controlled designs of complex colloidal nanoparticle system are one of the most significant challenges in nanoscience and nanotechnology. Therefore, systematic and planned studies providing better revelation are demanded. We report a multifunctional delivery platform-based liposome loaded with drug, iron-oxide magnetic nanoparticles (MNPs), and a gold shell on the surface of liposomes, were synthesized using a lipid with polyelectrolyte (layersomes) templating technique. MNPs and the anti-cancer drug doxorubicin (DOX) were co-encapsulated inside liposomes composed by zwitterionic phophatidylcholine and anionic phosphatidylglycerol using reverse phase evaporation (REV) method. The liposomes were coated with positively charge polyelectrolyte (poly-L-lysine) to enrich the interface with gold anion, exposed to a reducing agent to form a gold nanoshell, and then capped with thio-terminated polyethylene glycol (SH-PEG2000). The core-shell nanostructures were characterized by different techniques like; UV-Vis/NIR scanning spectrophotometer, dynamic light scattering (DLS), transmission electron microscope (TEM). This multifunctional system achieves a variety of functions, such as radiofrequency (RF)-triggered release, chemo-hyperthermia, and NIR laser-triggered for photothermal therapy. Herein, we highlight some of the remaining major design challenges in combination with preliminary studies assessing therapeutic objectives. We demonstrate an efficient loading and delivery system to significant cell death of human cancer cells (A549) with therapeutic capabilities. Coupled with RF and NIR excitation to the doxorubicin-loaded core-shell nanostructure helped in securing targeted and controlled drug release to the cancer cells. The present core-shell multifunctional system with their multimodal imaging and therapeutic capabilities would be eminent candidates for cancer theranostics.

Keywords : cancer thernostics, multifunctional nanostructure, photothermal therapy, radiofrequency targeting
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