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Comparison of dioleoylphosphatidylethanolamine-polyethylene glycol (DOPE-PEG) and sodium deoxycholate micelles on stabilization of short single-walled carbon nanotubes for doxorubicin loading and delivery

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Background and Aims: Single-walled carbon nanotubes (SWNTs) are a kind of nanomaterials with ultrahigh surface area that permits efficient loading of drugs. SWNTs offer advantages including high cargo loading, prolonged circulation time and intracellular transport of their cargo. They have highly hydrophobic surfaces. For biomedical applications, surface modification is required for stability, biocompatibility and low toxicity. Herein we aimed to functionalize SWNT surface by dioleoylphosphatidylethanolamine-polyethylene glycol (DOPE-PEG) and sodium deoxycholate (SDC) micelles and compare their efficacy in SWNT stabilization for biomedical application as a carrier for the cytotoxic agent, doxorubicin.
Methods: Shortening and water dispersion of SWNTs were carried out by ultrasonication in aqueous solutions at different concentrations of SDC or DOPE-PEG micelle. UV-vis-NIR spectroscopy was performed to determine the effective sonication duration and micelle concentration. The stability of SWNT dispersions were assessed over the time and in the presence of salt by macroscopic observation and UV-vis-NIR spectroscopy. Doxorubicin loading and release under different pH conditions were carried out.
Results: The least effective ultrasonication duration was determined to be about 8 hours. The effective concentration of SDC and DOPE-PEG was 10 and 0.1 mM respectively. Dispersions were stable in water for at least several weeks at room temperature but SDC prepared dispersions were prone to agglomeration in the presence of salt and doxorubicin. The critical DOPE-PEG concentration for stability in physiologic conditions was about 5 times its CMC. Doxorubicin loading was pH dependent and its release was stimulated in acidic conditions.
Conclusions: The stabilization method should be stable enough to bears physiologic conditions and prevents its agglomeration in vivo. Hereupon SDC (and presumably similar surfactants) seems to be useless for biomedical applications. pH-stimulated drug release, make SWNTs ideal as in vivo drug carriers; since the micro-environments in the extracellular tissues of tumors and intracellular lysosomes and endosomes are acidic.

Keywords: Carbon nanotube; PEGylation; Drug delivery