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NIR-triggered, on-demand drug delivery using lanthanide-doped upconverting nanolamps

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Localized and recurring delivery of drugs in the hour of need is of great importance in many clinical conditions such as in the treatment of solid tumors, post-surgical wounds and localized infections. This helps increase the drug efficacy and minimize the side effects of anesthetics. Lanthanide-doped upconverting nanoparticles (UCNPs) have emerged as excellent nanotransducers for converting longer wavelength near-infrared (NIR) light to shorter wavelengths spanning the ultraviolet (UV) to the visible (Vis) regions of the spectrum via a multiphoton absorption process, known as upconversion. Here, we report the development of NIR to UV–Vis–NIR UCNPs consisting of $LiYF_4$:Yb_3/Tm_3@SiO_2 individually coated with a 10±2 nm layer of chitosan (CH) hydrogel cross-linked with a photocleavable cross-linker (PhL). We encapsulated fluorescent-bovine serum albumin (FITC-BSA) inside the gel. Under 980 nm excitation, the upconverted UV emission cleaves the PhL cross-links and instantaneously liberates the FITC-BSA under 2 cm thick tissue. The release is immediately arrested if the excitation source is switched off. The upconverted NIR light allows for the tracking of particles under the tissue. Nucleus pulposus (NP) cells cultured with UCNPs are viable both in the presence and in the absence of laser irradiation. Controlled drug delivery of large biomolecules and deep tissue imaging make this system an excellent theranostic platform for tissue engineering, biomapping, and cellular imaging applications.

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The influences of surface molecular structure of carbon nanotubes on the stability of thermal conductivity enhancement of CNT NFs

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Statement of the Problem: Pristine CNT, which have a strong tendency to entangle with each other and to rapidly aggregate due to large hydrophobic surface area. CNT in the CNT-based NFs tend to quickly stratify and precipitate to the bottom of the container. Such rapid sedimentation, which can clog any flow channels, seriously decays heat transfer effectiveness, and renders practical engineering applications infeasible. Therefore, improving the stability is the key challenge to enable successful engineering applications of the CNT-based NFs. The purpose of this study is to reveal the influences of surface molecular structure changes of CNT on the stability of suspension and thermal conductivity enhancement of CNT NFs.

Methodology & Theoretical Orientation: In this study, multi-walled carbon nanotubes (CNT) was used as the objects of study, a mixed acid composed of nitric acid (HNO3) and sulfuric acid (H2SO4) was used as oxidative modification agent, and different oxidation acid treatment times were adopt to investigate the effect of structural changes of CNT on the stability of suspension and thermal conductivity enhancement of carbon nanotubes/ethylene glycol (EG) nano-fluids (CNT/EG NFs). The effects of oxidative acid treatment on the morphology and surface molecular structure of CNT were investigated by SEM, TEM, FTIR, respectively; and the influence of structure changes of CNT on the stability of suspension and thermal conductivity enhancement of CNT/EG NFs was evaluated by sedimentation observation method, centrifugation method and optical microscopy method and transient line heat source method.

Findings: The stability of suspension is proportional to the abundance of functional carboxyl group –COOH on CNT.

Conclusion & Significance: The formation of carboxyl group COOH plays a major role in improving the stability of suspension and thermal conductivity enhancement of CNT/EG NFs.

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