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ORIGINAL PAPER

Surface modification of quantum dots and magnetic nanoparticles with PEG-conjugated chitosan derivatives for biological applications

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In this paper, amphiphilic chitosan derivatives (*N*-octyl-*N*-mPEG-chitosan, mPEG = poly(ethylene glycol) monomethyl ether; OPEGC) were successfully synthesised via the Schiff base reduction reaction of chitosan and mPEG–aldehyde, or octanal, with chitosan acting as the backbone of the grafted copolymers, and mPEG–aldehyde providing the hydrophilic chain or octanal providing the hydrophobic alkyl chain. The synthesis was confirmed by characterisation employing Fourier transform infrared spectroscopy (FTIR) and ^{1}H NMR. In the subsequent procedure, water-soluble quantum dots (QDs) and iron(II,III) oxide (IO) nanoparticles, widely used as nanoprobes in medical applications, were produced by the incorporation of QDs or IO inside the polymeric micelle core. Finally, the optical properties of QDs incorporated into OPEGC (OPEGC@QDs) were characterised by UV-VIS spectroscopy, fluorescence spectroscopy, cell viability was obtained through MTT, and the morphology of their assembly formed in water were observed by atomic force microscope (AFM) and transmission electron microscope (TEM) and the QDs content of OPEGC@QDs was calculated following thermo gravimetric analysis (TGA). In addition, the properties of IO incorporated into OPEGC (OPEGC@IO) were characterised by vibrating sample magnetometry (VSM), FT-IR, MTT, TGA, AFM, and TEM. The results indicated that the OPEGC composite nanoparticles with size narrowly distributed, good water solubility, and low cytotoxicity were prepared here, which represented a high quantum yield or good super-paramagnetism.

Keywords: chitosan, poly(ethylene glycol) monomethyl ether, quantum dots, iron(II,III) oxide

Introduction

Due to their distinguishing optical and electronic characteristics, nanocrystals or quantum dots (QDs) with a CdSe core and a ZnS shell have attracted great interest for tumour imaging (Gao et al., 2004), bioprobes (Alivisatos, 2004) and many other areas of biomedical research (Chang et al., 2005; Wang et al., 2006). To date, the most successful and method of preparing highly luminescent II–VI QDs is the trioctylphosphine/trioctylphosphine oxide (TOP/TOPO) synthetic approach (Hines & Guyot-Sionnest, 1996; Murray et al., 1993; Qu & Peng, 2002). However, this method requires a high temperature and the QDs obtained are insoluble in water, which restricts their biological applications (Lee et al., 2000; Murray et al., 1993; Qu & Peng, 2002). Accordingly, a number of surface functionalisation studies have sought to make QDs water-soluble and biologically compatible (Bruchez et al., 1998; Uyeda et al., 2005; Wu et al., 2009a, 2009b; Zhao et al., 2009, 2010). Hence, a major challenge in this area is to find a general and versatile method for rendering high-quality hydrophobic quantum dots soluble in water and also active in bioconjugate reactions.

Another category of inorganic nanocrystal, also ex-

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