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Highly luminescent and biocompatible near-infrared core–shell CdSeTe/CdS/C quantum dots for probe labeling tumor cells

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ABSTRACT

In this study, double shelled NIR CdSeTe/CdS/C quantum dots (QDs) were synthesized by a liquid phase method. The as-prepared QDs showed low cytotoxicity and good biocompatibility due to the formation of carbon shell. The imaging of targeted Human cervical carcinoma cells (HeLa cells) indicates that the CdSeTe/CdS/C QDs have excellent optical properties and cell viability. These results clearly shows that the CdSeTe/CdS/C QDs can be a good candidate for bioapplications.

1. Introduction

In the last two decades, quantum dots (QDs) have drawn significant attention due to their size-dependent properties [1–5]. Compared with the organic dyes, QDs exhibit excellent water solubility, unique optical properties, narrow emission spectra [6], high chemical and photobleaching stability [7]. These advantages endow QDs the ability as a promising tool in some research areas – especially in bioimaging [8–13].

QDs with near-infrared (NIR) emission (650–900 nm) are particularly appealing in biological applications. Optical imaging of visible light is hampered by autofluorescence as well as light absorption, and scattering by biological tissue constituents. However, near-IR-emitting fluorescence imaging overcomes these challenges because biological autofluorescence and absorbance are both at their minima in the wavelength range of 650–900 nm [14]. To prepare high quality NIR-emitting QDs, synthesis of alloyed CdSeTe QDs is a good choice, because of its good optical properties, higher crystallinity and spatial compositional fluctuation [15]. Besides, the core/shell (CS) structures, which have a well-defined, onion-like structure with more than two semiconductor materials, can provide NIR-emitting QDs as well [16]. Moreover, it is possible to tune the emission wavelength in a larger spectral window than with two semiconductor materials alone.

In order to expand bioapplications of QDs, two fundamental prerequisites should be considered. They are good optical properties and low cytotoxicity [17]. From this point of view, the biological applications of cadmium-based QDs may be limited, since photo-oxidation can cause the release of heavy metal ions, which decreases the stability and results in the production of cytotoxicity [18]. Fortunately, this problem could be solved by capping QDs with some inorganic shells, including CdS, SiO_2 and PbS [19–21]. Despite the progress of CS QDs that has been made toward to decrease toxicity of QDs, it still remains a problem that the existence of Cd and Pb elements might cause the organ damage [22]. And the CS QDs with the SiO_2 shell ha the shortage of reducing photoluminescence intensity [23]. Another way to avoid the potential toxicity is to coat them with biocompatible layers, of which carbon material is a good candidate due to their excellent biocompatibility and low environmental hazard. A number of carbon materials capped QDs have been studied such as peptide [24], protein [25] and carbohydrates [26,27]. However, peptide is expensive and carbohydrates are usually suffered from the disadvantage of complex pretreatment.

QDs have been applied quite successfully in cell imaging, but specificity is still a problem, which hinders the further use in imaging. Recent efforts have demonstrated that chemical modification of labels on the surface of QDs can facilitate their targeting to specific diseased cells or tissues. Aptamer has been proven to be highly versatile for cell targeting [28–30].

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