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NIR-Emitting Alloyed CdTeSe QDs and Organic Dye Assemblies: A Nontoxic, Stable, and Efficient FRET System

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Received: 28 February 2018; Accepted: 30 March 2018; Published: 11 April 2018

Abstract: In the present work, we synthesize Near Infrared (NIR)-emitting alloyed mercaptopropionic acid (MPA)-capped CdTeSe quantum dots (QDs) in a single-step one-hour process, without the use of an inert atmosphere or any pyrophoric ligands. The quantum dots are water soluble, non-toxic, and highly photostable and have high quantum yields (QYs) up to 84%. The alloyed MPA-capped CdTeSe QDs exhibit a red-shifted emission, whose color can be tuned between visible and NIR regions (608–750 nm) by controlling the Te:Se molar ratio in the precursor mixtures and/or changing the time reaction. The MPA-capped QDs were characterized by UV-visible absorption spectroscopy, fluorescence spectroscopy, transmission electron microscopy (TEM), energy dispersive X-ray spectroscopy (EDS), and zeta potential measurements. Photostability studies were performed by irradiating the QDs with a high-power xenon lamp. The ternary MPA-CdTeSe QDs showed greater photostability than the corresponding binary MPA-CdTe QDs. We report the Förster resonance energy transfer (FRET) from the MPA-capped CdTeSe QDs as energy donors and Cyanine5 NHS-ester (Cy5) dye as an energy acceptor with efficiency (E) up to 95%. The distance between the QDs and dye (r), the Förster distance (R_0), and the binding constant (K) are reported. Additionally, cytocompatibility and cell internalization experiments conducted on human cancer cells (HeLa) cells revealed that alloyed MPA-capped CdTeSe QDs are more cytocompatible than MPA-capped CdTe QDs and are capable of ordering homogeneously all over the cytoplasm, which allows their use as potential safe, green donors for biological FRET applications.

Keywords: energy transfer; alloyed quantum dots; quantum dots-dye assemblies; cytocompatibility