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Highly stable and bio-compatible luminescent molybdenum disulfide quantum dots for imaging of alimentary canal in *Drosophila*

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ABSTRACT

Investigations on inorganic luminescent nanomaterials have always gained enormous attention of the science community for their possible applications in the fields of bioimaging and biomedicine. In this succession, various 0D structures including CdSe, CdTe, ZnS, graphene quantum dots (GQDs), carbon nanodots (CNDs) etc. have been explored for their possible applications in the field of biology. Recently, molybdenum disulfide quantum dots (MoS_2-QDs) have been explored as an alternative of graphene quantum dots (GQDs) for their possible applications in relevant fields. Herein we report a facile, eco-friendly and single step hydrothermal synthesis of in-situ functionalized molybdenum disulfide quantum dots (*f*-MoS_2-QDs). During the synthesis, variation in the pH of the starting solution provided the controlling over particle size. These as synthesized *f*-MoS_2-QDs have shown excitation dependent broad emission spectra, which could be fitted for a parabolic function. The broadening in the emission spectra might be attributed to the polydispersity of *f*-MoS_2-QDs in colloidal suspension, which was further confirmed with time resolved photoluminescence (TRPL) measurement. Due to surface capping provided by various functional groups present in the colloidal suspension, *f*-MoS_2-QDs have shown excellent stability in aqueous medium and only a 3% of decrement in PL intensity was recorded even after six months. These synthesized *f*-MoS_2-QDs possessed a quantum yield (QY) of 2.3% in aqueous media. Due to their high photostability and biocompatibility, these *f*-MoS_2-QDs have been revealed as a potential entrant for in vivo bioimaging in *Drosophila*.

1. Introduction

Since last few years, molybdenum disulfide (MoS_2), a member of transition metal dichalcogenides (TMDs) family has been intensively investigated as an alternative of graphene and graphene derivatives (graphene oxide, reduced graphene oxide etc.) [1,2]. Besides an exhaustive exploration of 2D MoS_2, its 0D structure (MoS_2-QDs) has also gained an enormous attention due to its strong luminescence property [3]. The luminescence property in QDs rises mainly due to their quantum confinement and edge effect which is better than the conventional fluorescent dyes in terms of long term photostability, highly resistant to photo bleaching and non-blinking nature [4]. MoS_2 is a class of layered materials which comprises a metal (Mo) layer sandwiched between two chalcogen (S) layers in the form of S-Mo-S linked with covalent bonds [5,6]. Interlayers of MoS_2 are joined together with weak Van der Waals interaction, which makes them suitable to be cleaved easily along their basal planes. Prominent photoluminescence (PL) has been also reported earlier for monolayer MoS_2 due to hybridization of p_z orbital of sulfur and d orbital of molybdenum (resulting indirect to direct band gap transition), which make it suitable for various optical applications [7]. However, the synthesis of monolayer MoS_2 is very challenging and on the other hand yield is also low making difficult its availability for large scale production. Additionally the PL quantum yield (QY) of MoS_2 is very sensitive to the number of layers and a maximum of 4×10^{-3} has been reported for monolayer [8]. On the other hand, there are several reports available regarding the synthesis of MoS_2-QDs with good yield, so making it suitable for large scale production [9,10]. Consequently, MoS_2-QDs may find applications in new generation photo detectors, microelectronics, nanomedicine, bio-imaging, pH based sensors etc [11–14].

As it is well known that several important biological applications of QDs require PL stability as well as biocompatibility. In this context PL stability and biocompatibility of a number of QDs have been investigated by various groups. Kim et al. used polydentate phosphine

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