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# pH dependent luminescence switching of tin disulfide quantum dots

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ABSTRACT

Designing a molecule with pH, temperature and ion concentration sensitive luminescence properties is always fascinating. Tin disulfide ($SnS_2$), a member of layered metal dichalcogenides (LMDs) family, is explored much for their commendable applications, however, its fluorescence property is still less explored. Present study reports a facile and eco-friendly bottom up synthesis route for tin disulfide quantum dots ($SnS_2$-QDs). Transmission electron microscopic (TEM), and Atomic force microscopic (AFM) analysis revealed an average particle size of ~3.6 nm. Our reported synthesis method provide the in-situ functionalization of quantum dots (QDs) making it highly sensitive to its environment. $SnS_2$-QDs are found to be pH sensitive and hence a detailed pH dependent luminescence study has been performed. Interestingly it was found that $SnS_2$-QDs possess ~16 fold enhanced luminescence intensity in acidic condition (pH ~ 1, QY = 5.32%) rather its basic condition (pH ~ 12, QY = 1.17%). To explain this pH dependent behavior of $SnS_2$-QDs, a mechanism has been proposed where this luminescence switching is mainly supposed due to protonation and deprotonation between $-NH_2$ and -COOH groups. We believe present study may provide an insight for the development of pH sensor using $SnS_2$-QDs for practical applications.

## 1. Introduction

In the last few decades, the colloidal inorganic semiconductor nano crystals or quantum dots (QDs) have gained enormous attention due to its excellent electrical, optical and charge transfer properties than its bulk counterparts. Several reports are available showing the strong luminescence properties of these inorganic quantum dots, which is attributed to its quantum confinement and edge effects [1]. Nowadays, graphene analogues inorganic layered materials have been intensively explored for their potential applications [2]. Among them the most studied are the transition metal dichalcogenides (TMDs) especially $MoS_2$ and $WS_2$, which have been investigated for their commendable applications in the field of next generation flexible electronics, optoelectronics and catalysis [3–5]. Due to their strong luminescence, better aqueous stability and bio-compatibility, QDs of TMDs have found applications in the field of sensing and biology [1,6].

Apart from the TMDs nanostructures, layered metal chalcogenides (LMDs) have also attracted much attention as an alternative of graphene due to their impending applications in the field of photodetectors [7], solar cell [8], photonics [9], chemical sensing [10], energy storage [11] and many more [12]. Tin disulfide ($SnS_2$), a member of LMDs, is an n-type semiconducting materials with an indirect band gap ranging from 2.1 eV to 2.6 eV depending on the morphology and number of layers of $SnS_2$ crystals [7,13]. Its wide band gap and high on/off ratio (~$10^6$), makes it a potential candidate for electronics and optoelectronics devices [7]. Structurally in $SnS_2$, one layer of metal atom (Sn) is sandwiched between the two layers of chalcogen atom (S) with strong in-plane covalent bonding and two such adjacent layers are bonded with weak interlayer van der Waals forces. Several reports are available showing promising applications of $SnS_2$ for sensors, lithium ion batteries, photodetectors, field effect transistors, splitting of water and many more. It is well known that transformation of bulk LMDs into its lower dimensional materials have shown exciting optical and physiochemical properties due to its quantum confinement and edge effects [14]. In this context $SnS_2$ quantum dots (QDs) have not been widely explored. Han Wu et al. have synthesized stannous sulfide and stannic sulfide quantum dots using ultrasonic method and studied its optical and electrical properties [15]. Xiao Fu et al. have reported the synthesis of $SnS_2$ QDs using hydrothermal method via liquid phase exfoliation technique [13]. Furui Tan et al. have used hot injection method for the

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