Development of aqueous synthesis pathway for CdSe quantum dots: A greener method

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Abstract: Cadmium Selenide (CdSe) is one of the most important and widely studied semiconductor of group IIB-VIA with a wide and direct band gap of 1.74 eV [1]. Due to the appropriate band gap energy in the visible light region, quantum dots (QDs) of CdSe show potential applications in the field of optoelectronics, light emitting diodes, solar cells and fluorescent probes[2]. To utilize these dots in the potential applicative fields, the primary criterion is the synthesis of these quantum dots in the biocompatible mode, adopting green chemistry principles. Therefore, synthesis of CdSe QDs in aqueous medium is most essential. However, aqueous synthesis of these vital QDs is found to be a little difficult one, due to the fast growth of particles in aqueous phase, resulting bigger particle size due to Ostwald ripening[2]. Therefore, keeping the size of the nanoparticles restricted within the quantum confinement, in water based synthesis process, is the primary concern. To resolve this issue, in the present work, we are reporting a developed green chemistry principle daqueous synthesis route of quantum confined CdSe nanoparticles using biocompatible Polyvinylpyrollidone (PVP) molecule as capping as well as stabilizing agent.

In this synthesis, Se was first reduced to Se^{-2} with $NaBH_4$ in water and the reduced Se^{-2} was further added to the freshly prepared Cd^{+2}-PVP precursor solution to prepare quantum dots of desired shape and size. The whole reaction was performed under inert atmosphere (N_2atm) and found that in this process the time consumption was very less (~ 10 minutes).

$$Cd(NO_3)_2.4H_2O + Se + PVP \xrightarrow[RT,\ N_2\ atm/H_2O]{NaBH_4} CdSe\text{—}PVP$$

$$Cd(NO_3)_2.4H_2O + PVP \xrightarrow{RT,\ N_2\ atm/H_2O} Cd^{+2}\text{—}PVP$$

$$Se \xrightarrow[RT,\ N_2\ atm/H_2O]{NaBH_4} Se^{-2}$$

The resultant CdSe particles were found to be within quantum confinement with powder X-ray diffraction (Figure a, size ~ 4.5Å) and high resolution transmission electron microscope (Figure b, size ~ 2.2 nm).

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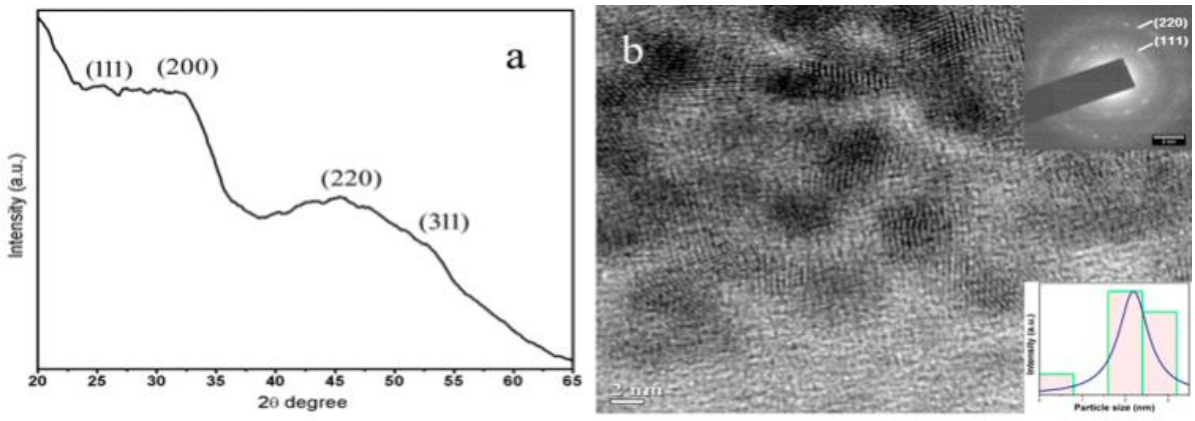

Figure: (a) Powder XRD analysis of CdSe QDs and (b): HR-TEM analysis of CdSe QDs.

We have successfully synthesized PVP capped CdSe QDs in water. This developed methodology is easy, cost-effective, less time consuming and involves minimum chemicals and energy (room temperature). PVP, being highly biocompatible in nature, is expected to enablethe CdSe QDs to be utilized as biomarkers, tracers and drug deliverers

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