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Morphological, Structural And Optical Characterization Of CdSe Quantum Dots

FORT HARE
Institute of Technology

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Introduction

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- High demand for energy supply has motivated the search for effective routes to fabricate devices that can meet the demand of sustainable energy.
- One significant development was the DSSC.
- Quantum dots (QDs) have drawn great interest as sensitizers in QDSSCs.
- Their tunable band edge offers new opportunities for harvesting light energy in most of the visible region of the solar spectrum.

Introduction

- It has also been reported that QDs generate multiple charge carriers with a single photon.
- Hence this project focuses on the synthesis and characterization of CdSe QDs.

Introduction

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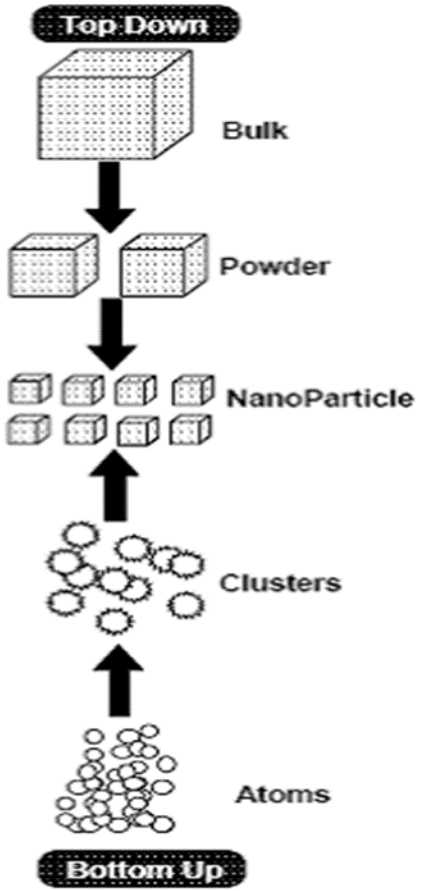
- Several processing methods have been used for CdSe QDs:



Top down Methods
-Wet chemical etching
Bottom Up methods
-Sol-gel
-Hot injection method

Aims And Objectives

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AIM

- Synthesis and characterization of CdSe QDs using the hot injection method.

OBJECTIVES

- Synthesis of CdSe QDs with different particle sizes.
- To evaluate the structural properties of CdSe QDs using FTIR and RS.
- To determine the crystalline and morphology of CdSe QDs by XRD and HRTEM.
- To evaluate the changes in QDs absorbance as the temperature is increased.

Experimental

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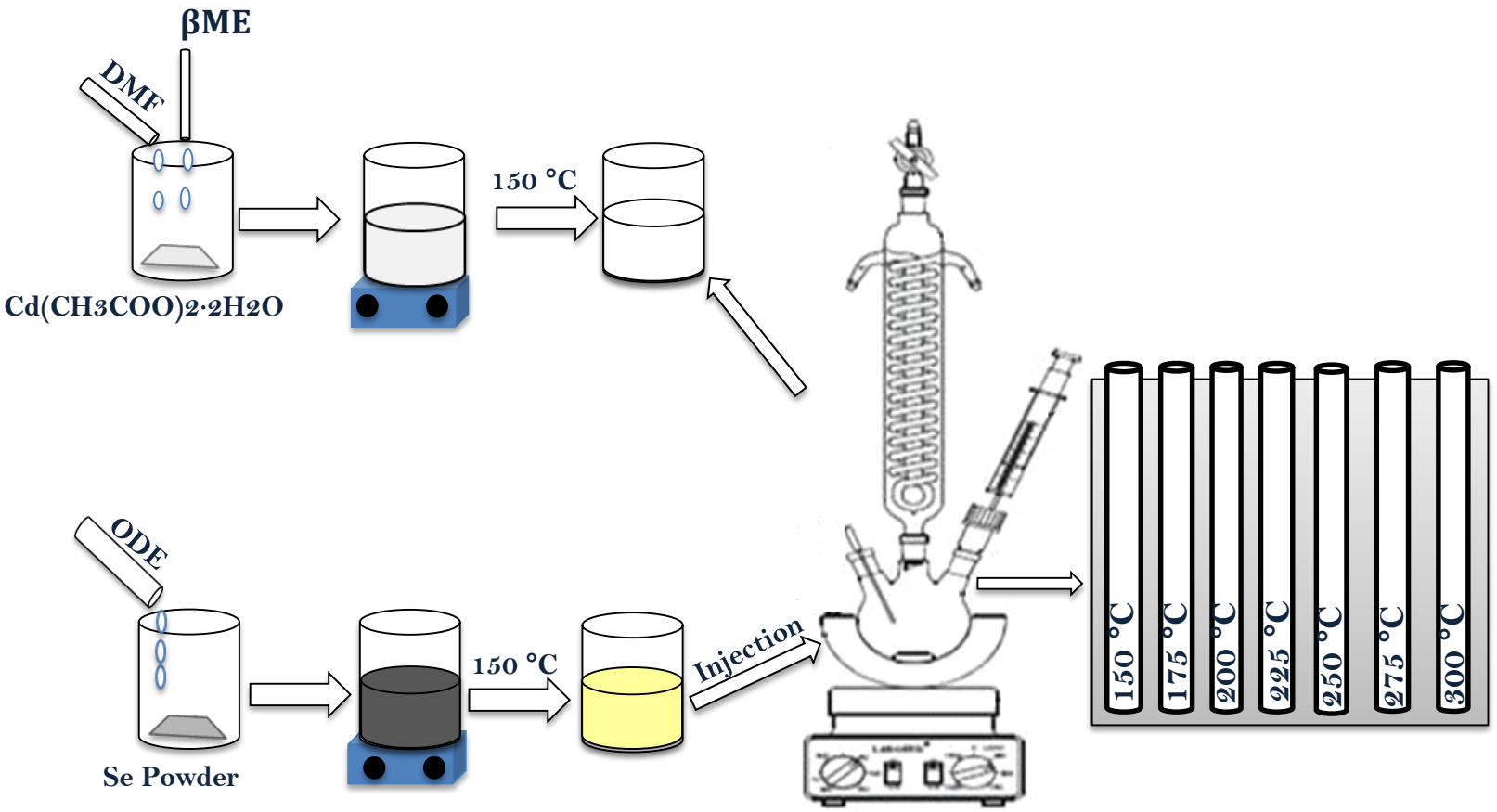
Condenser

Thermometer

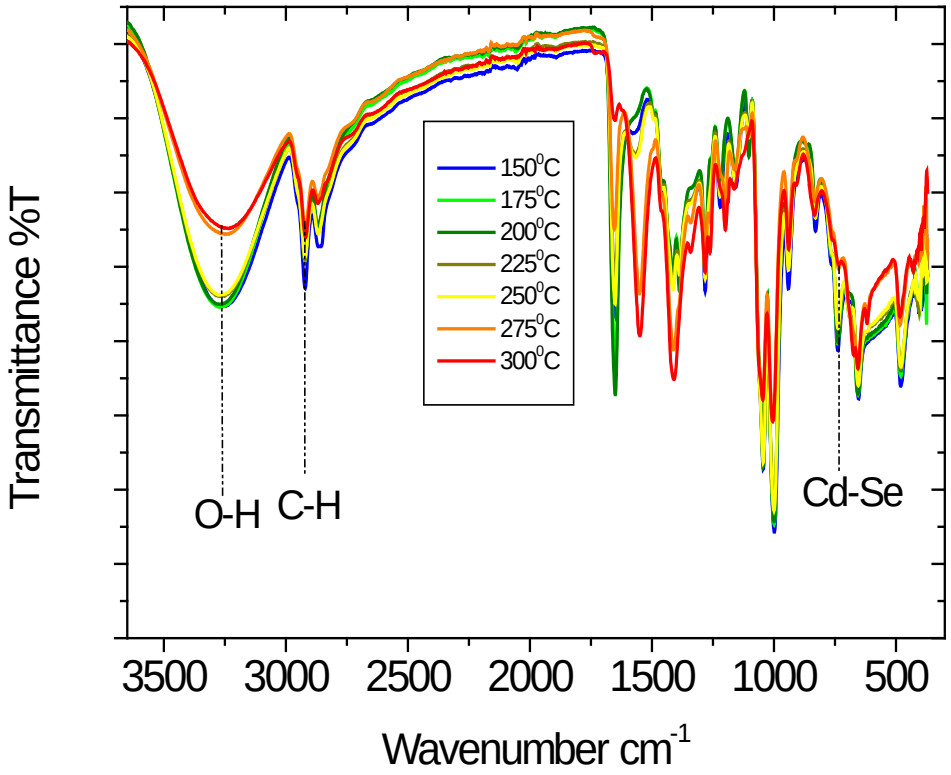
3-neck flask

Heating Mantle

Methodology

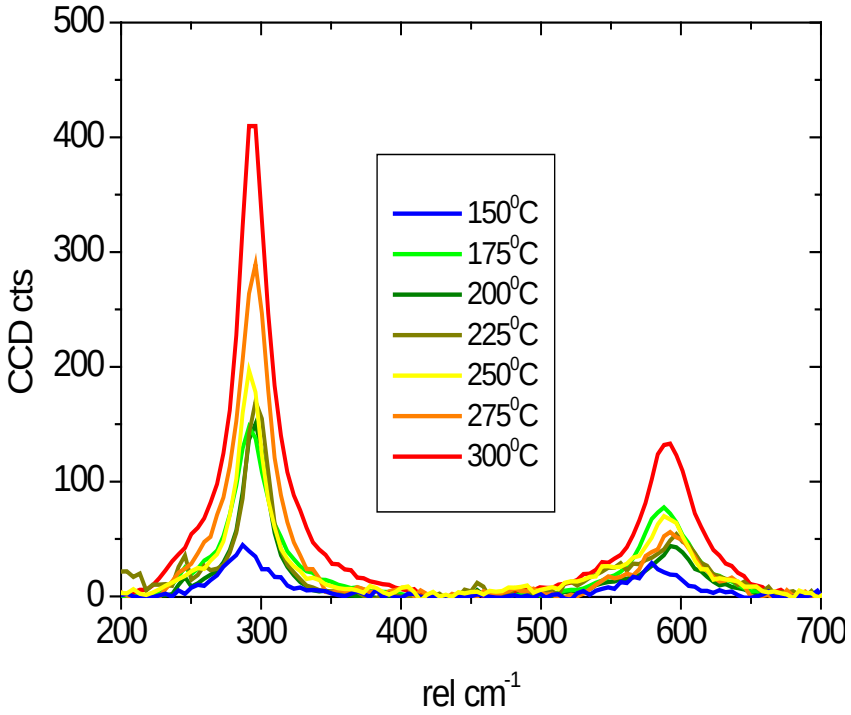


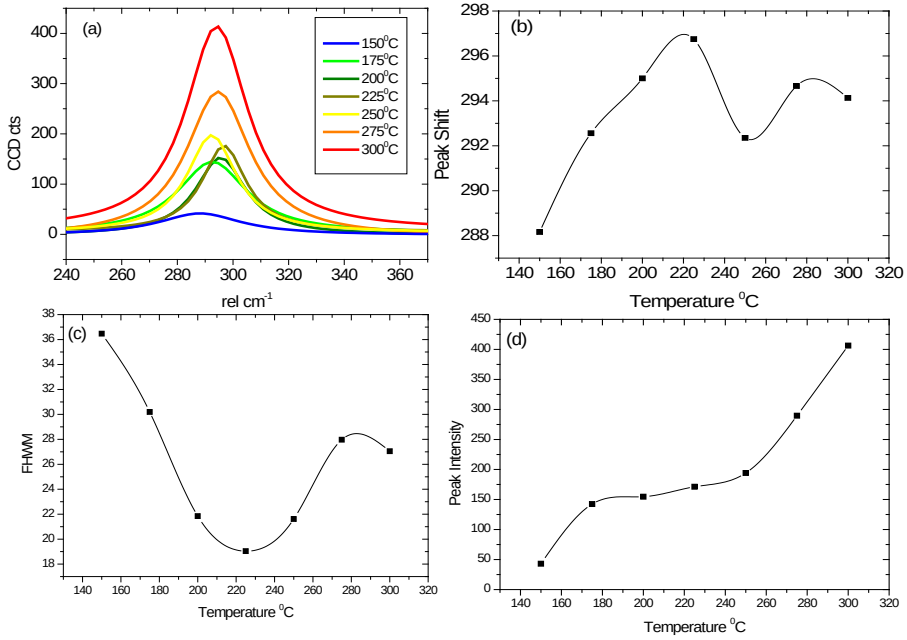
Results: FTIR



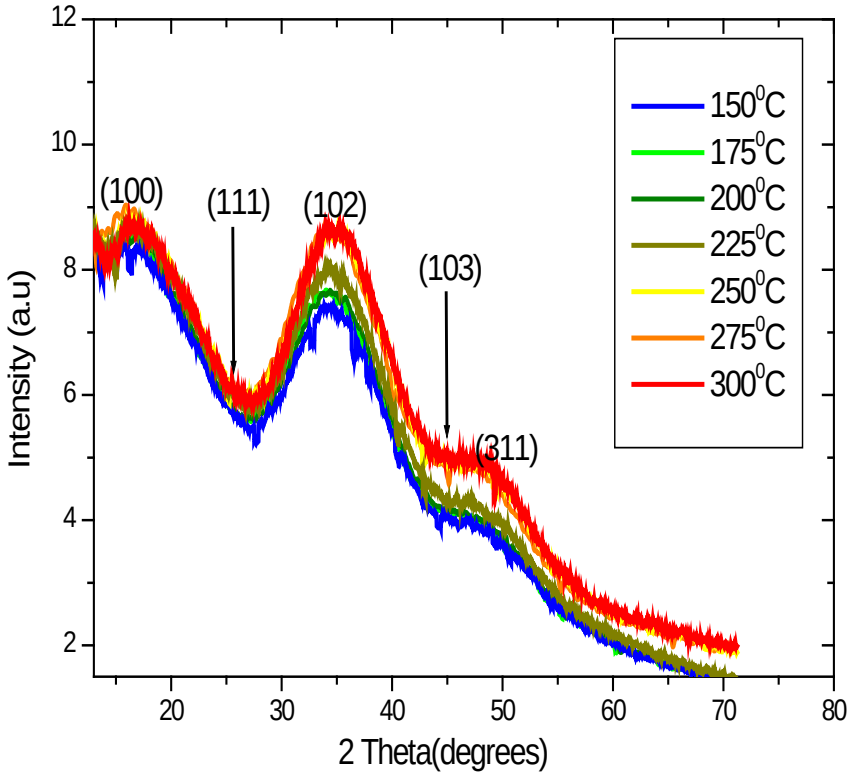
- The vibrational peak of Cd-Se bond was found at 738, 738, 738, 738, 735, 735 and 733 cm^{-1} for 150, 175, 200, 225, 250, 275 and 300°C, respectively.
- The presence of O-H, C-H and absence of S-H stretch confirms the successful capping of CdSe QDs.

Raman Spectroscopy





XRD



- The XRD peaks at angles $2(\theta)$ of $17.35°$, $25.18°$, $35.13°$, $41.63°$ and $45.7°$, corresponding to crystal planes (100), (111), (102), (220), (103) and (311),respectively.
- $\tau = {}^{K\lambda}/_{\beta cos\theta}$
- The average particle size calculated from this equation was 1.77, 1.82, 1.91, 1.96, 1.97, 3.11 and 3.14 nm.

HR-TEM

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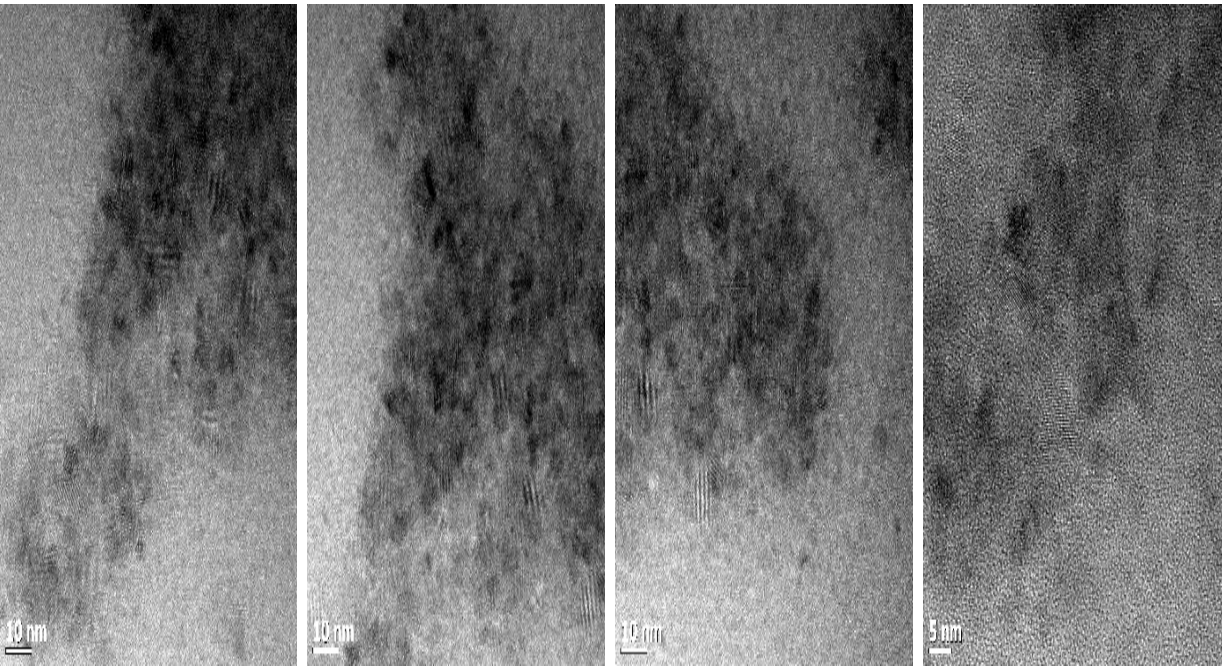
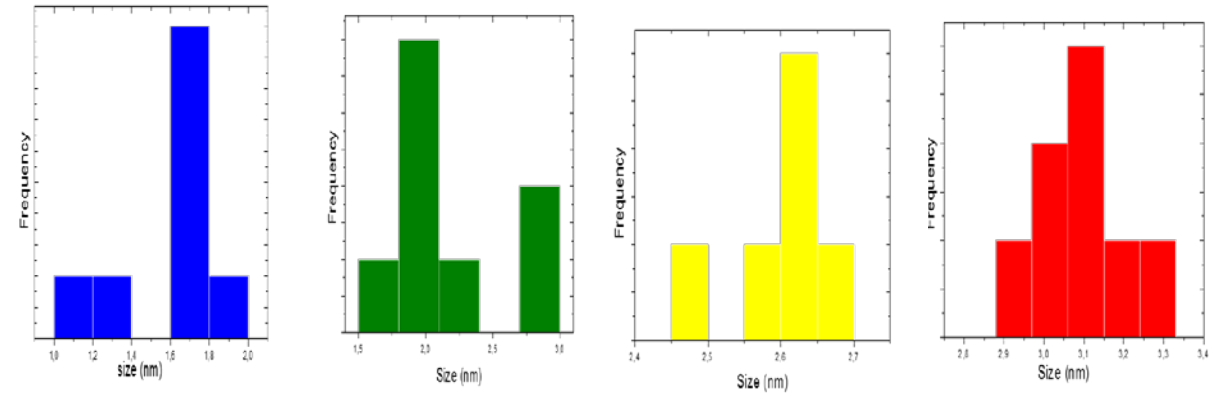
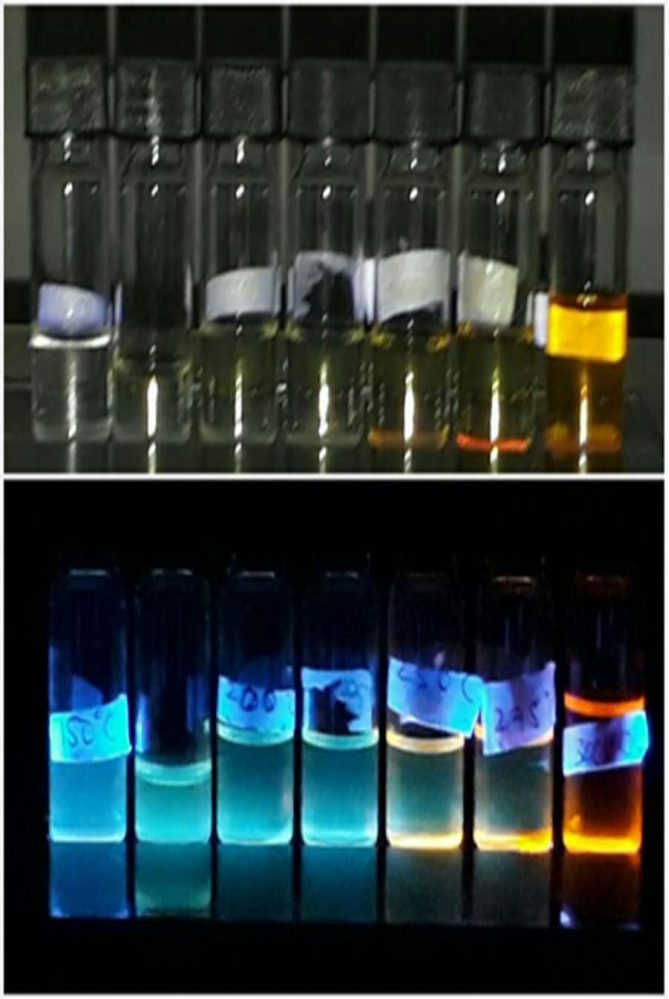




- HRTEM analysis has revealed that the synthesised CdSe QDs are spherical in shape.
- The histogram showed that the average particle size of the QDs ranges from 1.79, 1.81, 2.06, 2.08, 2.11, 3.10 and 3.12 nm.

Optical Characterization



- CdSe QDs have been successfully synthesized at various temperatures with an observable colour change.
- Under ambient light, the synthesized CdSe QDs appear colourless, to yellow, to reddish orange.
- A very clear distinction is observed between the colours of QDs observed in normal light and under UV light indicating the formation of QDs and their variation in particle size with rise in temperature.

UV-VIS

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Sample	Temp. of generated QDs ^{o}C	First peak of Wavelength (nm)	Size of CdSe QDs (nm)	Energy band gap (eV)
1	150	399	1.79	3.11
2	175	409	1.91	3.03
3	200	411	1.93	3.01
4	225	412	1.94	3.01
5	250	413	1.95	3.0
6	275	511	3.13	2.42
7	300	514	3.17	2.41

$$D = (1.6122 \times 10^{-9})\lambda^4 - (2.657 \times 10^{-6})\lambda^3 + (1.6242 \times 10^{-3})\lambda^2 - (0.4277)\lambda + (41.577) \quad [1]$$

$$Eg = h\nu = \frac{hc}{\lambda} \quad [2]$$

XRD, HRTEM and UV-Vis

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Sample	Temp. of generated QDs ^{o}C	XRD (nm)	HR-TEM (nm)	UV-VIS (nm)
1	150	1.77	1.79	1.79
2	175	1,82	1,81	1.91
3	200	1,91	2,06	1.93
4	225	1,96	2,08	1.94
5	250	1,97	2,11	1.95
6	275	3,11	3,10	3.13
7	300	3,14	3,12	3.17

Conclusion

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- FTIR confirms the successful fabrication and capping of CdSe QDs.
- XRD has shown peaks at $2(\theta)$ $17.35°$, $25.18°$, $35.13°$, $41.63°$ and $45.7°$ that confirm the wurtzite structure of CdSe QDs.
- RS and XRD revealed that the as synthesised CdSe QDs have a wurtzite structure.
- HRTEM & XRD analysis have revealed that the size of CdSe QDs increase with an increase in synthesis temperature.
- UV-Vis spectroscopy has revealed that there's a red shift in absorbance with increase in CdSe QDs particle size.

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