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# The influence of reaction times on structural, optical and luminescence properties of cadmium telluride nanoparticles prepared by wet-chemical process

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ABSTRACT

This paper explains one pot synthesis of type II water soluble L-cysteine capped cadmium telluride (CdTe) core shell quantum dots using cadmium acetate, potassium tellurite and L-cysteine as the starting materials. The reaction was carried out in a single three necked flask without nitrogen under reflux at 100 °C. Results from PL show a sharp absorption excitonic band edge of the CdTe core with respect to the core shell which loses its shoulder during the growth of the shell on the core. The PL spectra indicate a drastic shift in emission window of the core which is simultaneously accompanied by an increase in emission intensity. X-ray diffraction pattern confirms the formation of hexagonal phase for all samples. Some difference in absorption edges were observed due to varying synthesis time of CdTe NPs. The position of the absorption band is observed to shift towards the lower wavelength side for shorter durations of synthesis.



## 1. Introduction

There is a growing interest in study of semiconductor quantum dots (QDs) as fluorescence probes in cell imaging and biological labeling [1–6] due to their optical and electric properties. The size-controlled fluorescence properties of the nanoparticles, the high fluorescence quantum yields of QDs and stability against photo bleaching makes the QDs superior optical labels for multiplex analysis. The QDs show other good properties over classical organic dyes such as broad absorption spectra, very narrow emission spectra and long fluorescence lifetime [7,8]. These properties enable them to have a wide range of applications in optoelectronics, photovoltaic devices, optical amplifiers, telecommunication networks and also in bio-labeling for imaging, sensing, diagnosing and curing of diseases [9,10]. CdTe is a direct band gap semiconductor. The reported room temperature band gap of CdTe is in the range of 1.4–1.5 eV [11–13] ideally suited for solar radiation absorption. CdTe nanoparticle is classified as being unique due to its broad excitation wavelength which is found at the infrared region [14]. Synthesis parameters have considerable influence on particle sizes and photoluminescence quantum yield of the CdTe nanoparticles. These parameters include reaction temperature and time, the pH of the reaction solution and the molar ratio of the stabilizer to $Cd^{2+}$. In this study, CdTe nanoparticles were made by a simple green synthesis using L-cysteine as a capping agent and potassium tellurite as a stable tellurium source. The dimension of the core determines the band gap and hence the color of emission. It is known, that an increase in particle sizes produces a red shift in the emission spectrum [15]. In principle, the emission of nanoparticles can be coarse-tuned by the choice of the material and later fine-tuned by playing with the size of the core.

## 2. Experimental procedure

Chemicals used in this experiment include cadmium acetate, potassium tellurite, L-cysteine (purchased at polychem industries Durban South Africa) and sodium borohydride (purchased at Aldrich chemicals). CdTe nanoparticles were synthesized as follows: 0.5 mmol of Cd $(CH_3COO)_2 \cdot 2H_2O$ was dissolved into 125 ml of deionized water in a stand up flask. This was then followed by the addition of 0.06 g of L-cysteine with adjustment of pH of the solution to 11 using 1M NaOH solution. After stirring for 5 min, 0.1 mmol of $K_2TeO_3$ was dissolved into 125 ml of deionized water and was added to the precursor solution. After this 200 mg of $NaBH_4$ was then added into the precursor solution. However, the solution became light brown on addition of $NaBH_4$. After the reaction has occurred for 5 min, the flask was then attached to a

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condenser and refluxed at 100 °C under open-air condition. As synthesis time increases from 15 to 420 min, color changes from light brown to yellow then pink and finally to gray. The growth of the CdTe QDs was then monitored at different growth time for 15, 30, 60, 180, 300 and 420 min. The resulting mixture solution was heated to 100 °C under open-air conditions and synthesized at

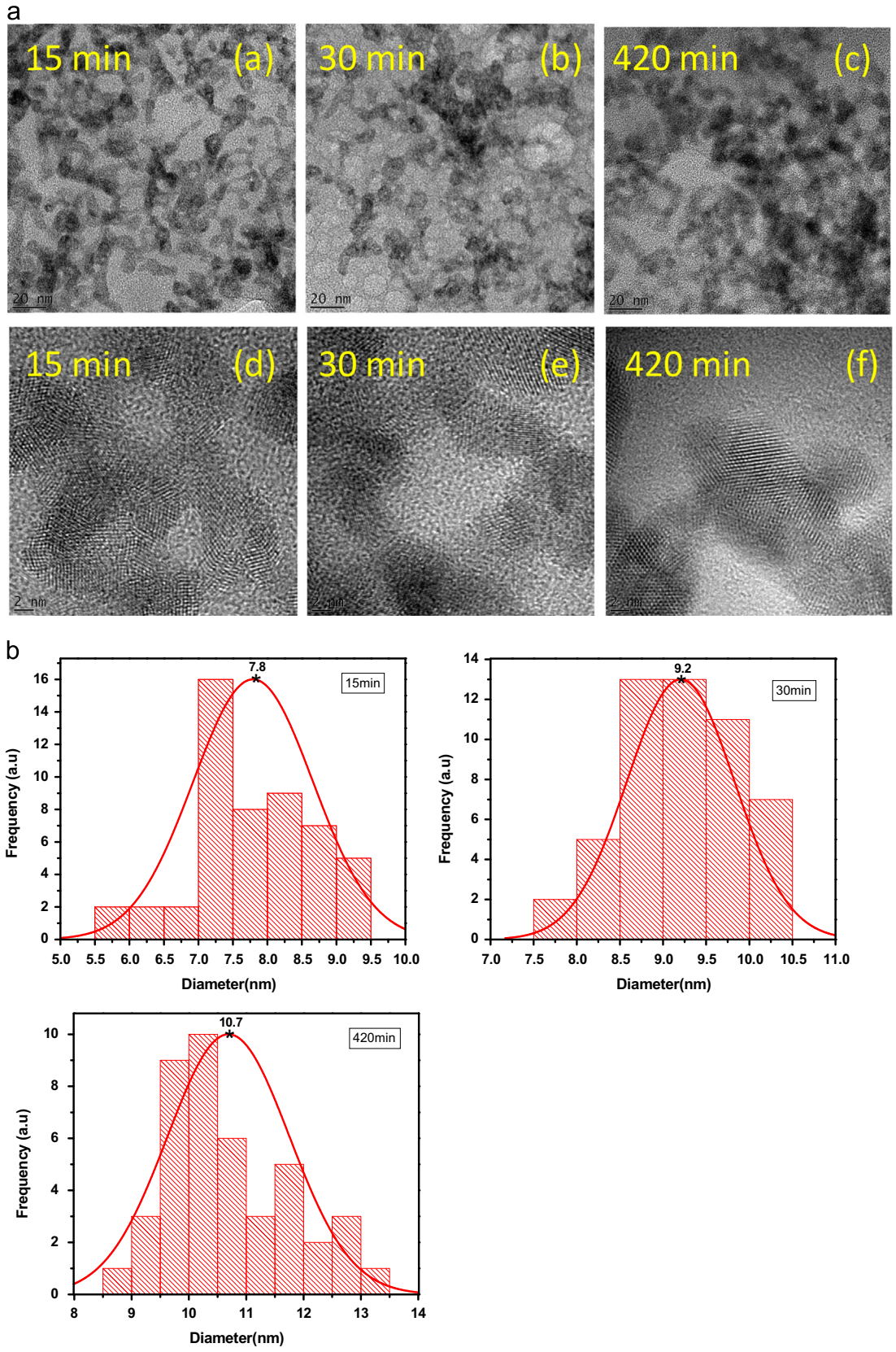


**Fig. 1.** (a) Representative TEM micrographs of CdTe samples taken from reaction solution after synthesizing time of 15, 30 and 420 min. (b) Histograms obtained from TEM micrographs of CdTe samples taken from reaction solution after synthesizing time of 15, 30 and 420 min.