The Optical Properties of CdSe Quantum Dots by Using Spray-Atomization Method

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Abstract.

Cadmium Selenide (CdSe) quantum dots (QDs) is inorganic material by using spray-atomization method which is the novelty to find out the optical properties for the CdSe QDs. The Selenium (Se) precursor and Cadmium (Cd) precursor were prepared first. Se precursor by using sodium sulfite aqueous was mixed with selenium (Se) powder. For Cd precursor was used cadmium chloride (CdCl\textsubscript{2}) as the Cd precursor. From previous research, CdSe QDs was obtained by using capping agent such as tri-n-octylphosphine oxide (TOPO) and trioctylphosphine (TOP). These capping agent are hazardous to environment and human. By using spray-atomization method it is more safe and economically. The photoluminescence (PL) was used to investigate the optical properties and to investigate the energy band gap from PL result. The field emission scanning electron microscopy (FESEM) was used to know the surface morphology of CdSe QDs. By PL result, the energy band gap was calculate and the comparison was investigate between the size of particle and the energy band gap. This important in this paper is to investigate the optical properties of CdSe QDs by using sprays-atomization method and to relate with the particle size.

Introduction

Cadmium Selenide (CdSe) is inorganic semiconductor material, CdSe was very potential in optoelectronic devices application such as solar cells, Light Emitted Diode (LED) and biosensors [1, 2]. From the previous research, CdSe QDs was clarified by using Chemical Vapour Deposition (CVD) method, spray-pyrolysis, hydrothermal and electrochemical [3-5]. CdSe QDs was used in many field in solar cells application, Light Emitted Diode (LED) and sensors [6, 7]. Quantum dots were well known as the smallest particle which have in nano size. Nano size basically in around 100 nm which is also known as nanoparticle or quantum dots.
(QDs), but QDs have unique properties when it is smaller the photoluminescence properties also change from red shift to blue shift [6, 8].

When the colour changed, the wavelength also changed. CdSe QDs have quantized energy which has 1.7 eV direct energy band gap [7-9]. The emission and absorption wavelengths of quantum dots depend on the nanoparticles diameter and called it as quantum confinement [10]. Quantum dots consists of narrow fluorescence and size distribution and has high quantum yield of emission [11].

From previous research, CdSe QDs were prepared by using in many capping agent as the stable colloidal of CdSe QDs to prevent irreversible aggregation, coagulation and fusion of the quantum dots [12-14]. The capping agent from previous basically paraffin liquid, oleic acid [14], vegetables oil [15] and tri-n-octylphosphine oxide (TOPO) [16]. TOPO chemical was hazard, unsafe and not friendly to environment and human [17, 18].

Material
Selenium powder was purchased from Sigma Aldrich with purity 99.5%, Cadmium Chloride (CdCl) was purchased from Sigma Aldrich, Sodium sulfite and ammonium hydroxide was purchased from Sigma Aldrich.

Experimental Set-Up
The glass substrates were washed by using acetone and methanol. In this project, Se precursor must be prepared first. The preparation of Se precursor; 8.0 g of Se powder was mixed in excess 0.2 M of sodium sulfite aqueous solution to completely dissolve Se powder and was heated at 70°C in for 8 h with magnetic stirring. For Cd precursor, the 0.1M of cadmium chloride (CdCl) solution was added to 0.1 M of sodium selenosulfate solution. Finally the pH solution was titrated to 12.0 by ammonium hydroxide solution to get stable clear solution. The mixture between Se precursor and Cd precursor were added to become Cadmium Selenide (Case). The solution was using spray-atomization method which is the parameter was variables from 10 min to 50 min. The characterization in this project was used FESEM for surface morphology and photoluminescence spectroscopy (PL) for optical properties. The droplet size was depend on many parameter such as flow rate, nozzle structure and spray distance. But in this paper the main parameter was time of spray at certain time to optimize the optical properties of CdSe QDs.

Diagram 1 The Flow Chart of The Overall Experiment
Result and Discussion

Figure 1 The FESEM image for CdSe QDs at 25 min of spray process.

To study the surface morphology and structures, the field emission scanning electron microscopy (FESEM) was performed. The Figure 1 is for surface morphology by using FESEM with magnification 1kx, 10kx and 50kx. This magnification from the overall surface with magnification 1kx and was zoom in 10k and 50kx to know the size and shape of structures of CdSe QDs. The size of particle become small when the time of spray-atomization increase, this is because the growth of particle increase when the time increase and the size of particle become small [3]. From the previous study, the particle was growth when the time of spray increases. The CdSe precursor was spray on the glass substrate at 10 s and was left for 20 s for to form crystalline CdSe QDs [3]. When sodium selenosulfite was used as a Se source to produce CdSe QDs via spray-atomization, sulphate was inevitable formed which could contribute to crystalline size of CdSe Qds [3]. Morphology was zoom at different magnification because to know the surface morphology of CdSe QDs at different view.
To study optical properties the CdSe QDs, CdSe QDs was observing by using photoluminescence spectroscopy (PL), the higher peak was observed at 25 min, second at 20 min and third 15 min. The PL shows the spectra of the QDs at room temperature with laser source 325 nm. The experimental result show that the quantum dots samples have different intensity and wavelength effects of the radius difference. As the reaction time increase the intensity of PL increases and the shift start to change from left to right which is start to red shift. The intensity at 25 min was higher than other because of the particle growth higher than other and the size of particle was increases [3]. From Figure 2, the wavelength was increase from 15 min to 25 min from 556 nm to 575 nm and as the time increase from 15 min to 25 min, the shift was changed from left to right, which was toward to red shift. Red shift has higher wavelength and higher in size. The intensity was optimize at time 15 min to 25 min.

Figure 2 Photoluminescence result from time 15 min, 20 min and 25 min.

Figure 3 The energy gap for each parameter at different time
Table 1 The comparison of particle size and energy band gap for CdSe QDs in different parameter.

From the peak of PL result, and the Figure 3 show the energy band gap was calculated to know the relation between photoluminescence and energy gap. The energy band gap was calculated and plot with the diagram Figure 3 and Table 1. From the result, when time of spray increases the energy gap was decrease. From the theory, when energy gap decrease the nanoparticles size were also increase. It is related with the wavelength from PL result the wavelength was shift from left to right which is the wavelength increases. As the wavelength increase, the energy gap increases because energy band gap inversely proportional with wavelength. The result showed the particle size was increase when time of spray-atomization increases. As the size of nanoparticle was reduced, the role of surface increases [19]. From the result above, when particle size become smaller, the energy gap will be increase [20].

Conclusion

CdSe QDs can be obtained by using spray-atomization method which was using the time as the variables parameter. The optical properties of CdSe QDs were defined by photoluminescence (PL) result and surface morphology by using FESEM. From the all result, it can be state that the time of spray of CdSe was gave the effect on the size and optical properties to CdSe QDs. The particle size of CdSe quantum dots was increase as the time of spray was increase, as the particles growth very fast.

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