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The Effect of Avocado Peel Extract on the Optical Properties of Cadmium Sulfide Nanostructures

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Abstract

In this work, avocado peel extract was used as a capping and reducing agent for preparing cadmium sulfide nanoparticles. UV. Visible spectrometry (UV-V)is spectrophotometry was used to study the absorbance and to found the optimal conditions for formation CdS nanoparticles. The band gap was found to be 3.25 eV, suggesting the effect of quantum size. The X-ray diffraction(XRD) pattern explain that the as-formation CdS particles are crystalline with cubic phase. Field Emission Scanning Electron Microscope (FE-SEM) images explain that the nanoparticles have spherical shape with an average size of 22 nm. The optical properties of CdS NPs such as the coefficient of absorption, refraction, and diffraction were calculated using mathematical equations.

Keywords: plant extract, CdS NPS, FE-SEM, XRD, optical properties.

1. Introduction

Researchers have studied the optical and structure properties of semiconductors because of their unique and distinctive properties. Their shape, size, and crystal structure are affected strongly by their properties. Semiconductors (quantum dots) have numerous applications in laser beams [1], electrochemical cells [2], biological markers [3] and electrical gadgets. Cadmium sulfide is one of the semiconductor materials that is most widely studied because of its unique characteristics. A prominent characteristic of CdS is its broad band gap energy of 2.42 eV at ambient temperature. [4], which explains why optoelectronic devices require them. [5, 6] and, aside from their usage as a temporary material, in solar cells [7, 8] .CdS nanostructures are used as a pigment in engineering paints and plastics due to their thermal and chemical stability[9].

In addition, CdS nanocrystals have excellent optical properties that can be used in laser sensors[10, 11], optical filters[12], and light-emitting diodes [3, 13].

Ultimately, the photo catalytic properties of CdS compounds reveal their use as a photomitigator for pollutants from water, where hydrogen can be generated with the help of solar power by splitting water molecules.[14, 15].CdS exists in nature in three crystalline states: the high-pressure rock salt phase, the zinc mixture, and the wurtzite phase. The latter is found in large-scale and nano-sized[16, 17].In addition, it is possible to convert from one phase to another by changing (temperature, concentration, particle size, components of the raw material). For example, it is possible to convert from the wurtzite phase to zinc or vice versa, and the most stable phase is the wurtzite phase.[14] .CdS nanostructures have been prepared by many chemical and physical methods such as microwave heating, micro emulsions and sonochemical preparations. Although most of these methods are still used successfully, there are many problems associated with them such as the use of (hazardous solvents and hazardous materials) which could lead to risks. Some of these methods use ultrasonic waves and high heat, which can affect the crystalline structure of the prepared nanostructures. Furthermore, some techniques use high-energy lasers to exfoliate or deposit the nanostructures, which is so expensive. An alternative method can be used to form nanostructures. This method is called green synthesis and is widely used in the synthesis of metal and semiconductor NPs.[18, 19] This method relies on the use of plant parts such as (roots, leaves, and peels) as reducing agents and covering agents. It is an environmentally friendly, easy and cheap way to create materials at the Nano scale. In the literature, many studies on the formation of semiconductor molecules from plant extracts have been reported [20]. However, little work has been conducted on methods of plant extracts to form CdS nanostructures. In this project, Avo peel Ext (AVO), was used for the first time to fabricate cadmium sulfide Nano crystals. This extract acts as a capping agent that is expected to prevent or reduce the aggregation process of CdS nanoparticles and control their stability.

2. Methodology

2.1 Avocado Extract

Avo plant was obtained from the market and then washed well with deionized water to remove suspended contaminants. After that, the peel of the avocado plant was taken the extract was ground and dried for two days. It was prepared by taking 100 ml of deionized water and dissolving 10 grams of the powder in it. By (heating, stirring) for 8 minutes at a temperature of 70°C, then we filtered the extract using filter papers, and cooled before using**.**

2.2 Synthesis of CdS Nanoparticles

To preparation of 1 mmol of cadium sulphide, a suitable amount of cadmium chloride was dissolved in 50 ml of deionized water and stirring for half an hour at ambient temperature. In the same way sodium sulphide was prepared and stirred for half an hour.[21]. To the CdCl solution, different amounts of the extract were added and stirred for 10 minutes, after that Na2S was slowly added to the solution. The solution was left for a quarter of an hour while continuous stirring. For optical studied, the solution was taken directly to UV-Vis spectroscopy to record its absorbance. However, to study the structural properties the solution was transfer to the centrifugation to separate the particles at a speed of up to 4000 revolutions from the suspended materials. After that, the formed particles were washed with deionized water and then dried for 3 hours at 100°C and stored in a dry place.

2.3 Best Conditions for Formed CdS Nanoparticles

To determine the best conditions for the formation of CdS nanostructures in the found of (Avo) extract, many conditions were studied, such as, the Ph , the effect of time of solution, and the Conc of the Ext. After establishing the optimal conditions for preparing CdS. The prepared particles were be a subject for measurement using different technique such as FESEM and XRD.

3. Result and Discussion

After mixing)Na2S) with the solution contained (CdCl2) and Avo peel ext, the(A) spectra were recorded immediately (0 h) and then after 2, 4, and 6 h. It seems (see Figure 1) that the absorption of CdS nanostructures effected by reaction time. As, the absorption of light by CdS molecules will increase and the interference of CdS molecules will increase. Therefore, 6 h is considered the best reaction time for producing CdS nanoparticles which given absorption edge of 405 nm.

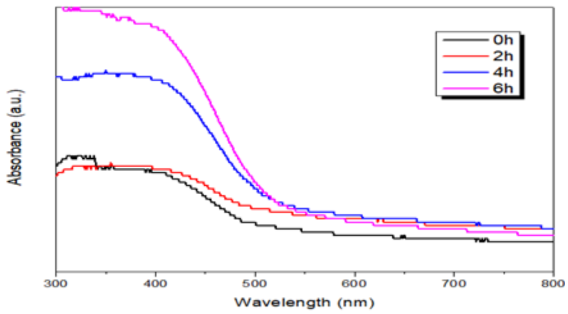

Figure 1: show absorption and effect reaction time

At the lowest concentration of the extract, 2.5 ml, the absorption peak did not appear clearly. When the amount of extract was increased to 5 ml, we noticed the presence of a weak peak at about 323 nm. This would clarify the synthesis of the CdS structures. By increasing the amount of the extract to 10 ml, a significant increment in the absorption intensity and a blue shift around 120 nm with respect to the bulk CdS were noticed. Due to the quantum confinement effect, this blue shift (which appears when the size is less than 10 nanometers) can occur.

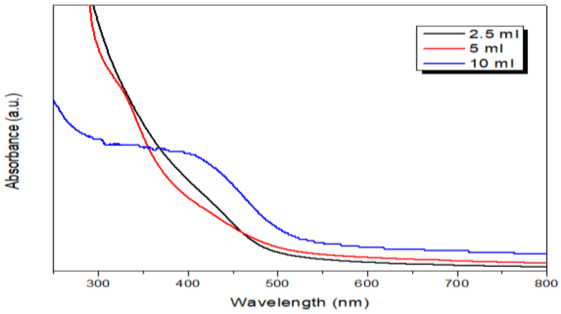

Figure 2: Ultraviolet-visible spectra of cadmium sulfide nanostructures using change amounts of avo extract (10,5,2.5 ml).

Hydrochloric acid and NaOH were used to adjust the pH of the solution and study the effect of pH on the absorption of CdS nanostructures, while the extract (peel) was stable at room temperature (10) ml.cadmium sulfide were prepared at different PH (3, 5, 7, 8, 9, 11, and 12). The original acidity of the prepared structures was 5. In acidic conditions, The smallest absorbance value was obtained at around 335 nm, indicating the preparation of CdS nanostructures. Increasing the NaoH of the solution increases the amount of adsorption of CdS structures at pH 11. We observed the highest absorption spectrum clearly appearing at the peak at 395 nm, indicating the formation of cadmium sulfide nanostructures with larger sizes when compared to those with smaller ones. At (~10 nm) a red shift occurred compared to bulk CDs when the pH was adjusted to 12 with a significant decrease in absorption peak intensity.. This decrease can be attributed to the formation of cadmium hydroxide due to the increase in OH- concentration, which leads to the reduction of Cd+2 ions in the sample. As a result, the amount of CdS nanostructures is less.

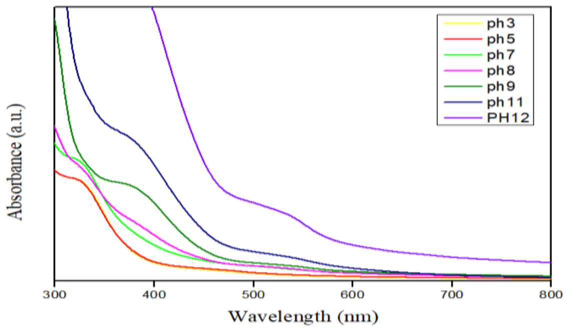

Figure 3: UV-visible spectra for CdS NPS formed in the found of A. peel ext as a function of the PH.

The band gap energy of CdS structures at pH 11 and 10 mL of (extract) was found using the Tuack equation.[22]

$\alpha h\nu = C (h\nu - Eg)n$ ………..(1)

Where n equals 0.5, which is the direct electronic transfer, and hv is the energy of the photon, for example, it is the band gap power, and α is the absorption coefficient. Figure 4 shows that the band gap energy of the formation structures (3.35) is greater than that of the bulk cadmium sulfide, which is related to the effect quantum confinement.

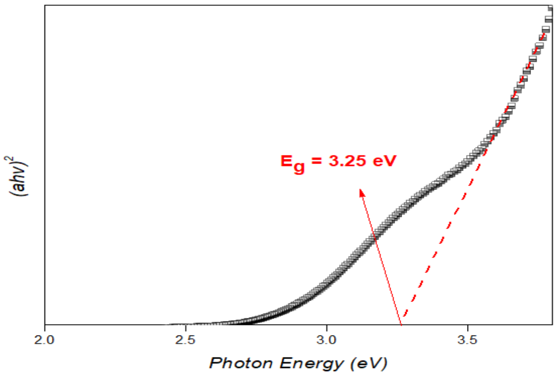

Figure 4: The B. g power of (CdS) nanoparticles.

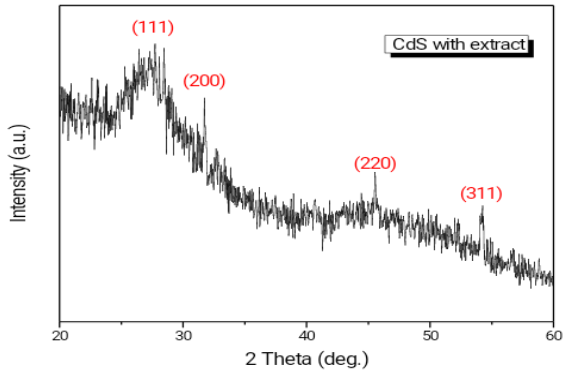

Figure 5: XRD for CdS particles prepared with the found of A. peel ext.

Figure (5) shows that CdS structures are crystalline. Four peaks appeared in the XRD pattern, at 27.7˚ (111), 32.8˚ (200), 45.7˚ (220), and 55.4˚ (311). The size of the cadmium sulfide crystals formed was found to be 2.5 nm using the equation.

From the TEM picture in Figure 6 we can see that the cadmium sulfide structures have spherical shape, and due to the presence of the A. peel, which acts as a protective agent, the agglomeration of the particles cannot be seen. The large light that show in the right picture may be the result of the bonding of the CdS crystals during the drying process on the TEM grid.

The surface morphology of CdS nano was examined by (FE-SEM). The majority of CdS molecules appear to have rectangular.

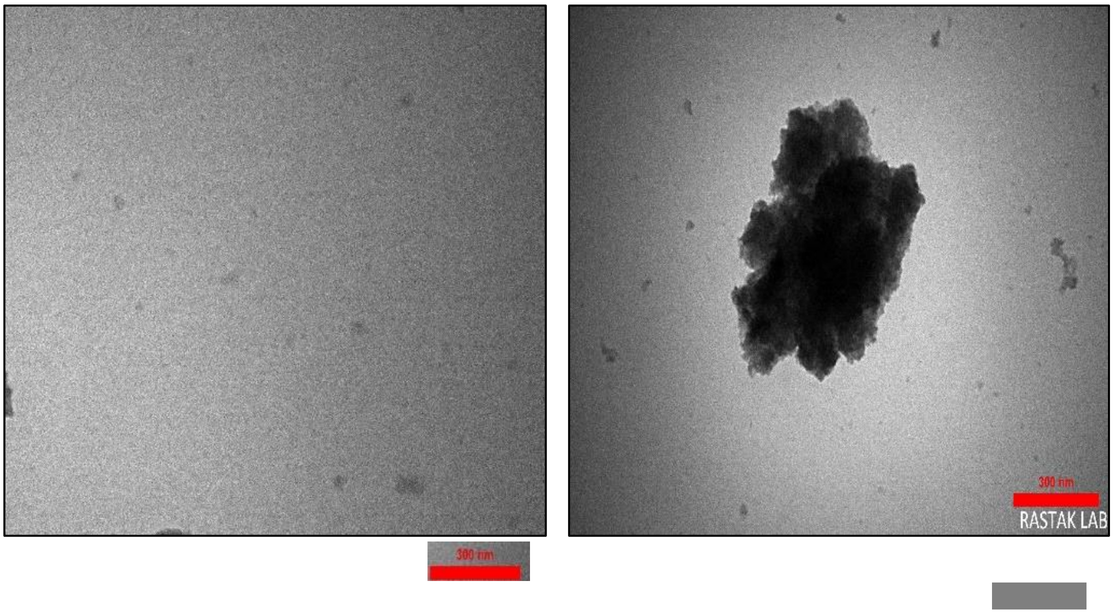

Figure 6: TEM picture of CdS structures prepared in the found of A. extract (peel).

3.1 Transmittance

Figure 7 showed the spectrum of electromagnetic radiation ranging between (400-800) nanometers. It is clear that the transmittance spectrum increases as the PH decreases from 11 to 5.

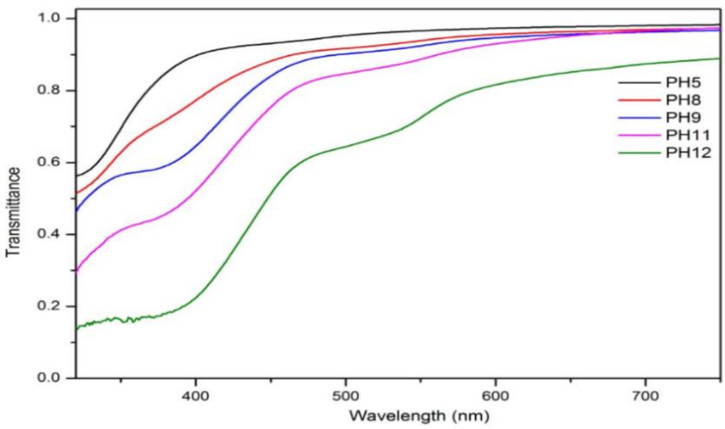

Figure 7: T. of CdS Nano in change pH.

3.2 Reflectivity

Reflectivity is the remainder of electromagnetic radiation when it returns to the location of the medium from which it was formed due to its collision with the solution. It also represents the amount of radiation remaining after some of it has been absorbed and another part has been absorbed.

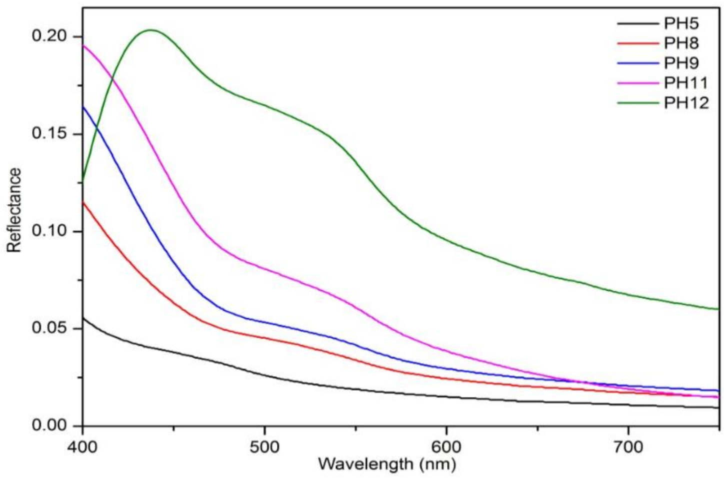

Figure 8: Reflectivity of CdS(NPS . A)With different PH.

3.3 Absorption Coefficient

We notice that the absorption coefficient increases with increasing pH, as shown in Figure (9) , and this is due to the formation of cadmium sulfide nanostructures in the presence of the extra presence of the extract.

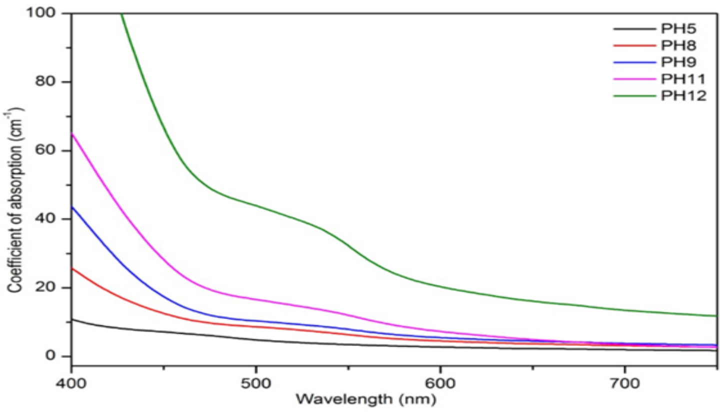

Figure 9: A. coefficient of CdS Nano at different pH.

3.4 Refractive Index

The refractive index was calculated from Equation (1) for the sample at different pH solution. Figure (10) explain the change in refractive index values versus the change in energy of incident photons as a function of changing pH within the wavelength range between (400-800) nm.

$$n_{\circ} = \left[\left(\frac{1+R}{1-R}\right)^2 - (K_{\circ}^2 + 1)\right]^{\frac{1}{2}} + \frac{1+R}{1-R} \ldots\ldots\ldots\ldots 1[23]$$

3.5 The Extinction Coefficient

It represents the amount of attenuation of the electromagnetic wave when it passes through a physical medium[24, 25], and during this process its value is determined by the interference that occurs between the electromagnetic wave and the physical medium. Figure (10) shows that the shape of the decay coefficient curve is similar to the behavior of the absorption coefficient, and the reason is due to the nature of the previous relationship. As pH increased, the extinction coefficient of the solution increased, and when the pH of the solution was reduced, we noticed a noticeable change in the values of the extinction coefficient. The peak of the absorption spectrum was clear at 335 nm (PH 3) and the highest absorption spectrum was at 393 nm (PH 11).

Table 1: The difference between the optical properties of two species; Cd(pH11), Cd NPs: Avo.

λ, max (nm)	A	T	R	α (cm^{-1})	K	n	CdS nano	Eg (eV)
445	0.1714	0.9837	0.07257	13.359	4.4789E-07	1.7672	CdS (pH11)	2.67
400	0.9480	0.6216	0.19674	66.0981	2.0832E-06	2.5969	CdS NPs: A	3.35

4. Conclusions

Cadmium sulfide nanostructures were prepared for the first time using Avo peel extract. It was prepared with improved physical and chemical properties, which are expected to have an effect on the formation of cadmium sulfide nanostructures (conc of Avo peel ext, reaction time, pH of the solution), and that the best PH for the formation of cadmium sulfide structures. It is pH11 with 10 ml of Avo peel extract, and from the X-ray diffraction curve, we conclude that our prepared CDS particles are crystalline, 2.5 nanometers in size, with elongated spherical shapes. Through studying the optical properties, it is clear that the permeability increases with increasing PH**.**

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