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Synthesis and Characterisation of CdS Nano Particles by Using Ultrasonic Wave Irradiation in Aqueous Medium

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Abstract:

Ultrasound to chemical reactions and strategies is the utility of Sonochemistry. The apparatus producing sonochemical consequences in liquids is the occurrence of acoustic cavitation. In sonochemical strategies the researchers have objective to study the results of sound waves and sound properties on chemical reactions or systems. The goal of this investigation is to synthesize quick and facile technique for the synthesis of CdS nanoparticles. Aimed at the current examination we used Cadmium Acetate and Sodium sulphide in aqueous medium, by means of the usage of consistent frequency ultrasonic wave irradiation. The resultant creation is investigated through the usage of X-ray diffraction technique (XRD), UV spectroscopy, and Scanning electron microscopy (SEM). Throughout the Course of response the enlarge in the temperature used to be happened because of absorption of ultrasound waves remained controlled comfortably by means of ice bath.

Keywords: Sonochemistry; CdS nanoparticles; U.V.; XRD; SEM.

1. Introduction:

Now a days Nano crystals of the transition metals and the main leading group elements have attracted much interest due to their unique thermoelectric, semiconducting and optical properties. Semiconductor of sulphides have in the past determined applications as sensors or laser materials, optical filters, photo voltaic cells and in many other devices[1].In the midst of these materials, CdS is particularly fascinating due to its excessive photosensitivity [2], which brands it as outstanding n-type window material in hetero-junction solar cells [3].Using n-type CdS, photo voltaic cells of one of a kind

efficiencies were fabricated [4]. However, a similar enhancement in the effectivity is viable through using Nano crystalline CdS. It is well known that crystals with dimensions in the nanometer range exhibit characteristics that are notably unique from the characteristics of bulk materials.

Many techniques have been promoted for the synthesis of group II–VI semiconductors. Normally few methods, like solvo-thermal method, thermo chemical methods, co-precipitation method, sol-gel method, hydrothermal method, colloidal method etc.[5–12], are adopted for preparation. A direct combination of elements in amine has been suggested two [13]; however, the obtained produce were amorphous and had to be crystallized at improved temperatures. The group of Gedanken et al. used microwave-assisted techniques for the instruction of metallic solenoids [14,15]. Recent reports include the bacterial biosynthesis of CdS Nano crystals. Chemical reactions such as oxidation, reduction, dissolution and decomposition, which have formerly been exploited to put together nanoparticles [16,17].Ultrasonic waves as a result have been appreciably used for producing novel substances with unusual properties. They can induce the formation of particles with a remarkably smaller size, which generally show novel physical houses [18].The interest imports from the one of a kind properties of materials in the Nano scale rule, such as a giant surface-to-volume ratio and extended floor activity, as compared to that of the bulk material. In our laboratory, the sonochemical approach has been successfully used in the synthesis of nanoparticles of CdS.

The first synthesis of CdS nanoparticles by using ultrasonic irradiation was reported by Wang et al. [2, 19, 20]. The technique used for the response of a mixed solution of cadmium chloride and sodium thiosulphate in isopropyl alcohol in an Argon atmosphere. A sonochemical approach to the synthesis of CdS nanoparticles the use of Cadmium acetate and elemental S in dimethyl sulfoxide under a H2/ Ar atmosphere was once also mentioned [1]. Recently, Behboudnia and Khanbabaee said on the synthesis of CdS nanoparticles via the sonication of an ethylenediamine solution of 1-decanthiol, Cadmium acetate and elemental S [21] and the sonochemical guidance of CdSe nanoparticles from cadmium acetate, tartaric acid, freshly organized sodium selenosulfate and tiophenol [22]. However, to the best of our knowledge, the sonochemical synthesis of CdS from aqueous options has no longer been mentioned so far. A direct, simple and well-known method, avoiding the necessity of the use of inert atmospheres and non-aqueous systems, seems to be required.

This preparation induces some changes in physical and chemical properties. Among the various methods as mentioned earlier, the ultrasonic irradiation method is chosen for the preparation in this work.

The optical band gap energy of the CdS is a significant parameter which supports to design photovoltaic cells. A very few researchers worked on the preparation of CdS nanoparticles by irradiation process apart from other methods [15, 16]. In this paper we present a new, simple method to prepare CdS nanoparticles at the constant frequency ultrasonic wave irradiation from aqueous solutions in the ambient atmosphere. The behavioral response and structural formation of the prepared sample are analyzed by using XRD, UV, and SEM.

2. Experimental Procedure:

Cadmium Sulphide (CdS) nanoparticles were prepared by constant frequency Ultrasonic wave irradiation. The raw materials were used for the precipitation as an analytical grade 0.2 M cadmium acetate (CH3COO)2 Cd2H2O and 0.2 M sodium sulphide (Na2S). The 5.33g of Cadmium Acetate and 1.56 gm of Sodium Sulphide were dissolved in hundred milliliters of de-ionized water individually in two beakers. The solutions were combined collectively underneath regular stirring by the use of magnetic stirrer at room temperature for one hour. The mixed solution turned into yellow color solution. This process was carried out until the solution color changed into greenish yellow. The deposited precipitate in the solutions were transferred into round bottom flask and further stir for 3 hours at room temperature. Then it is irradiated for 3 hrs through ultrasonic wave of constant frequency 40 KHz by using the use of sonication bath (Ultrasonic tub mannequin – ATS-3-LCD Analytics a hundred H, 3.5l capacity). The resulting precipitate is washed with de-ionized water more than ten times. The acquired yellow color product was dried up for 15h at 100°C to remove the water content. The resultant samples were again annealed at 400°C. The prepared samples were labeled as PM2.The prepared CdS nanoparticles were characterized with an X-ray powder diffractometer. Surface morphology of each samples were observed by using High Resolution Scanning Electron Microscopy. The atomic percentage of CdS nanoparticles was measured by using Energy Dispersive X-ray analysis (EDAX).

3. Results and Discussion

3.1. Structural analysis:

XRD analysis was carried out to study the structure and particles size of CdS nanoparticles using ultrasonic wave irradiation method. Fig. 1 shows the XRD patterns of CdS nanoparticles annealed at 400°C. The intensity peaks were obtained between 24° to 29°. (# PDF JCPDS No. 80-0006- The peaks in **Fig. 1** such

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as (100), (002), (101), (102), (110), (103), and (112) of CdS nanoparticles) for sample (PM2) belong to hexagonal phase [25].There are some additional peaks apart from CdS are observed. These peaks belong to CdO formation along with CdS formation. It is well matched with (#JCPDS No. 75–0592 - The corresponding impurity peaks at 2θ values such as 33°, 38.5°and 55.3°). The crystalline size of the nanoparticles was calculated by using the Debye - Scherrer's formula,

$$D = \frac{0.94\,\lambda}{\beta \cos \emptyset}$$

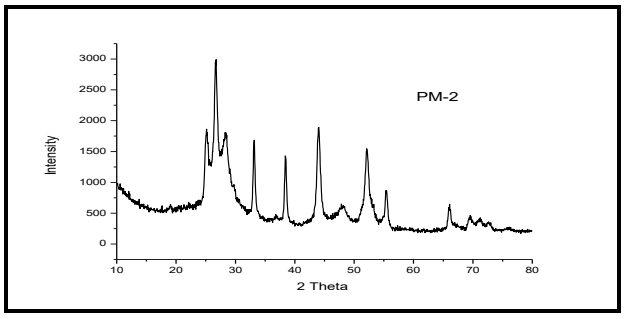

Fig. 1. XRD patterns of CdS nanoparticles PM2

where, D is the grain size, K is a constant of value 0.94, λ is the wavelength of the X ray radiation , β is the full width half maximum and θ is the angle of diffraction. The crystalline size is predicated by the Debye - Scherrer's formula as 23- 60 nm for PM2 sample.

3.2. U.V analysis:

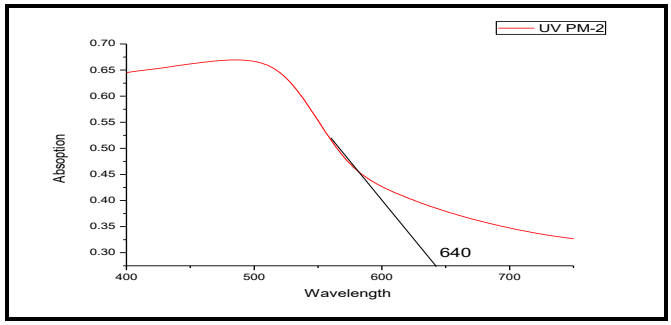

Fig. 2. UV-vise Spectra of CdS nanoparticles PM2

El	AN	Series	Unn. C (% wt)	Norm. C (% wt)	Atom. C (At %)	Error 1 Sigma (wt %)
O	8	K-Series	1.40	2.35	11.00	0.96
S	16	K-Series	8.52	14.36	33.52	0.39
Cd	48	L-Series	49.45	83.29	55.48	1.65
		Total	59.37	100	100	

UV-visible absorption spectrum was recorded for CdS nanoparticles in the range between 400 nm and 800 nm and it is shown in **Fig.2** The absorption occurred in the range of 490 nm to 550 nm for the samples prepared [11,26]. Then rapid fall in UV absorption is observed in this case. The range of fall in absorption after 520 nm. The band gap value is obtained from the plots of absorption with respect to wavelength. The band gap value is predicted for PM-2 1369/640 = 2.13eV. The ultrasonic irradiation process has made dissociation of NaS and produced S^{2-} which is combined with Cd^{2+} to form CdS.

3.3. Energy Dispersive Analysis of X-ray (EDAX).

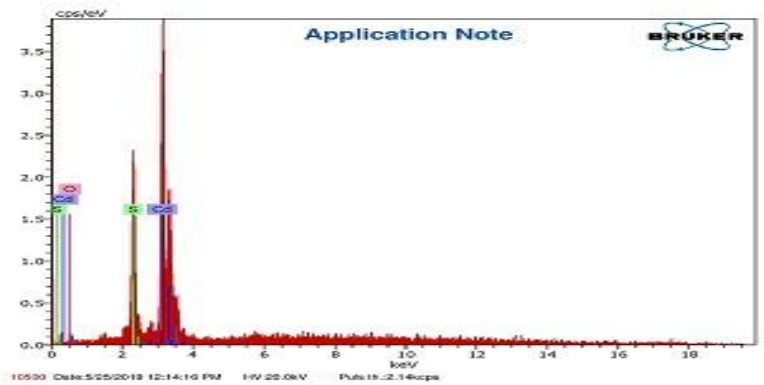

Fig.3. EDAX analysis of CdS nanoparticles PM2

The purity and composition of synthesized CdS nanoparticles are found by using Energy Dispersive X-Ray (EDAX) spectrum and it is found that it contains 48% Cd, 16% S and 8% Oxygen by weight. The presence of chemical constituents and some impurities are observed in the samples from this EDAX analysis. The presences of other elements like Na, C and O in the sample as impurities are originated probably from precursor material for synthesis. The presence of oxygen leads to the formation

of CdO nanoparticles as impurity during the nanoparticles preparation. The presence of CdO nanoparticles as impurity is clearly observed from the XRD spectrum.

3.4. High Resolution Scanning Electron Microscopy (HRSEM)

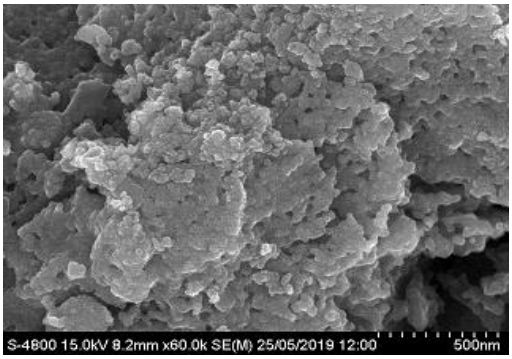

Fig. 4. SEM image of CdS nanoparticles

The HRSEM images of CdS nanoparticles are recorded is shown in **Fig. 4.** The appeared morphology shows a slightly agglomerated hexagonal shaped CdS nanoparticle. This result shows that the surface morphology of the CdS nanoparticles is strongly influenced because of ultrasound wave irradiation.

4. Conclusion:

CdS nanoparticles have been successfully synthesized by using constant frequency ultrasonic wave irradiation via a novel sonochemical route. The preparation method is relatively simple in comparison to other reported methods, avoids the use of an inert atmosphere, and uses less hazardous precursors and environmental friendly aqueous solvents. The average size of Nano crystallites was below 50 nm for the CdS. The products were characterized with powder diffraction analyses and thermal analyses including characterization of the intermediates. The crystal structure changed from hexagonal. SEM observations indicated that the particles were agglomerated, but con-firmed their hexagonal structure and uniform composition. The obtained nanoparticles are expected to be applicable in modern optoelectronic devices and solar cells. Further investigations may lead to the preparation of a variety of metal chalcogenides using similar preparation methods in aqueous systems.

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