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# Synthesis and Characterisation of Ternary Semiconductor Nanoparticles Blended with Medicinal Leaf Extract

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**Abstract:**

The characterizations of synthesized CdZnS nanoparticles with *Lawsonia inermis* leaf extract were done by the chemical precipitation method. The formation of CdZnS nanoparticles with the extract was confirmed using XRD, SEM analysis and EDAX. XRD revealed the structure and the particle size. SEM analysis of CdZnS NPs confirmed shape and size. The optical studies were done for the prepared sample. From the obtained UV-visible absorption spectrum, band gap energy was calculated using the Tauc plot.

**Key words:**

*Lawsonia inermis***,** Chemical precipitation, bandgap energy, Tauc Relation

## Introduction:

Nanotechnology is the art and science of introducing matter at the nanoscale to create new and unique materials and products with enormous potential to change society. Nanoparticles can serve as “magic bullets”, containing herbicides, chemicals, or genes, which target plant parts to release the content. [8]

Semiconductor nanoparticles (NPs) are made from a variety of different compounds. They are referred to as II-VI, III-V or IV-VI semiconductor nanoparticles, based on the periodic table groups into which these elements are formed. Semiconductor nanoparticles have attracted immense attention due to the size dependent optical and electrical properties that can be varied by adjusting the particle size. Semiconductor nanoparticles have applications in various fields like biological labeling and diagnostics. Devices based on nanoparticles properties can fabricate several optical and magnetic properties by changing the size that can be changed by the synthesis method [6]. The nanomaterials can be utilized in various fields since their potential physical and chemical properties are unable to drain from their bulk state. In addition, the electronic and optical properties of the materials are the key factors that decide the performance of the devices.

Group 2-6 semiconductors are otherwise known as chalcogenides, CdS, and ZnS which have direct band gaps of 2.4 eV and3.7 eV respectively. They can produce fast electron-hole pairs and the highly negative redox potentials of excited electrons make them effective catalysts. [3] Cadmium Zinc Suphide is a ternary alloyed semiconductor that has

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fine and tunable absorption in the visible region of solar energy so that they are widely used as wide band gap materials.

Lawsonia inermis is a middle-sized shrub medicinal plant with many branches. All of Its parts can be used as medicines for various diseases like headache, leprosy, dysentery and other skin disorders. Using oil boiled with Lawsonia inermis leaves promotes hair growth. As medicinal plant Lawsonia inermis is used as an astringent, anti-hemorrhagic, intestinal antineoplastic, cardio-inhibitory and sedative. The Lawsonia inermis extracts exhibit antibacterial, antifungal and ultraviolet light screening activity.

Green synthesis or phytosynthesis of nanoparticles is a widely used eco-friendly approach [9] [10] [11] [12] [13]. This method is a simple alternative to chemical and physical methods due to its low cost and less use of toxic chemicals. CdZnS is selected for the current experiment because of its wide applications. In the present study, the leaf extract of Lawsonia inermis (Mehendi) was used because of its medicinal properties [14]. Plants are rich in phytochemicals particularly secondary metabolites such as tannins, terpenoids, and flavonoids that have been demonstrated to have antibacterial properties [14] [15]. The present study focuses on the comparison of the antibacterial property of CdZnS nanoparticles synthesized in the presence and absence of leaf extract of Lawsonia inermis (Mehendi). It is hypothesized that the use of leaf extract as a capping agent would improve the antibacterial property of the CdZnS nanoparticles.

**Experimental**

Materials and methods

Cadmium acetate, zinc acetate and thiourea were weighed in 2:1:2 ratios. Cadmium acetate and zinc acetate were dissolved in water taken in a beaker, the desired amount of triethanolamine was added, and then the solution was mixed with ammonia and thiourea. After adding each compound the solutions were stirred thoroughly with a magnetic stirrer. The Lawsonia inermis leaves were collected, washed with de-ionized water and dried. The leaves were then grinded well and squeezed to get the extract. The extract was then mixed with the prepared solution.

The solution was kept in a constant temperature bath. A greenish yellow coloured precipitate obtained was centrifuged, washed with deionised water and the precipitate was kept in a hot air oven at 80$^{o}$C for $1\,{}^{1}/_{2}$ hour. The greenish yellow coloured precipitate was then powdered using agate mortar.

The prepared sample was subjected to XRD characterization using a Bruker $d_2$ Phaser X-ray diffractometer. The data were recorded over a range (2θ) θ from 0$^{o}$ to 80$^{o}$ with a step size of 0.02$^{o}$ and of wavelength 1.50460 Å.

The surface morphology of the nanoparticles was determined using Carel Zeiss, EV018 scanning electron microscope.

Optical absorption spectra of the synthesized sample were recorded on the Perkin Elmer UV-visible spectrometer, model- Lambda35 in the wavelength range 190nm to 1100nm.

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Elemental composition of the sample was analysed with the energy dispersive analysis of X-ray (EDAX) spectroscopy using TESCAN VEGA3 SBH EDS instrument connected to Versatile Tungsten Thermionic Emission SEM System - VEGA4

**Results and discussion**

1. XRD analysis

The structure of the synthesised nanoparticles was analyzed by XRD measurements. The XRD pattern (fig 1.) shows that the sample possess a zinc blended (cubic) structure. An additional peak was found in the pattern when 20 ml of Lawsonia inermis extract was added it may due to the presence of biomolecules. The partcle size for both pure CdZnS and Lawsonia inermis added CdZnS were calculated using Debye Scherrer formula

$D=0.9\lambda/\beta\cos\theta$,

where D is the average crystalline size, λ is the wave-length in Angstrom, β is full width at half maximum and θ the Bragg's angle. It is found that the particle size increased by adding extract. The intensity of the peak found to be decreased.

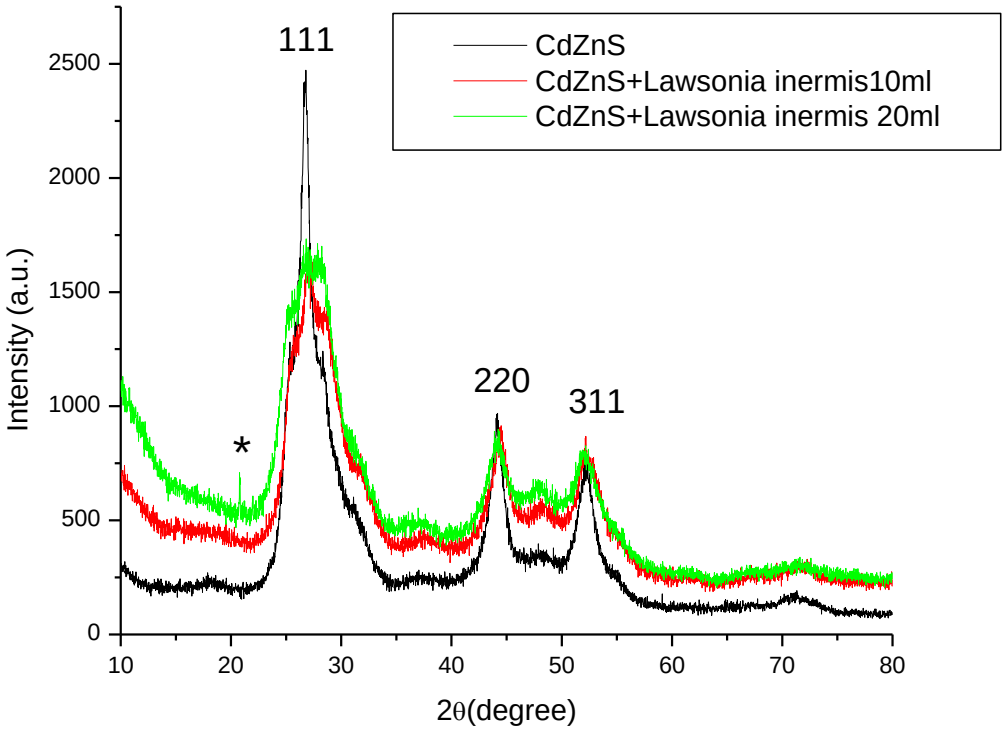


**Figure 1 XRD pattern for CdZnS and Lawsonia inermis added CdZnS nanoparticles**

2. Optical studies

The optical properties of CdZnS nanoparticles and Lawsonia inermis added CdZnS nanoparticles were investigated. The bandgap energy of the prepared samples was also analysed using UV- visible absorption spectroscopy. Figure 2. reveals the absorption spectra of CdZnS and Lawsonia inermis added CdZnS in two different concentrations in the wavelength range 200-800 nm.

The particle size of the nanoparticles and defects in the structure are factors that can change the absorbance of the samples. The UV-visible absorption spectra show the cut-off

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absorption of Lawsonia inermis added CdZnS nanoparticles shifts to lower energy (higher wavelength) compared to CdZnS nanoparticles. The absorption edge is found to shift towards a higher wavelength (red shift) ie the bandgap decreases as the particle size increases.

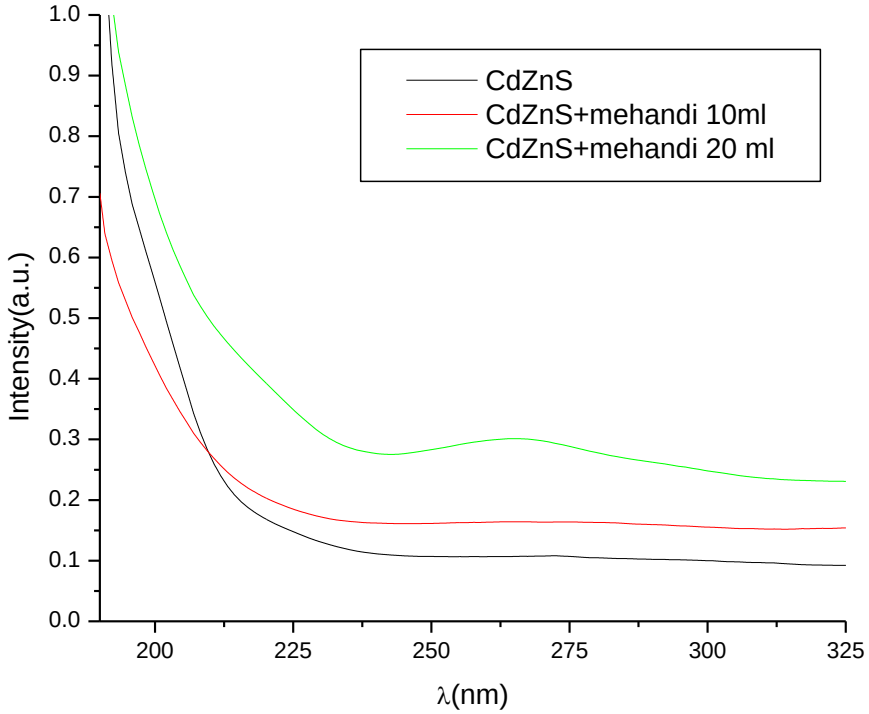


**Figure 2.The absorption spectra of CdZnS and Lawsonia inermis (10 ml and 20 ml) added CdZnS**

The bandgap energy of the prepared samples was calculated using the Tauc relation

$$\alpha h\nu = C(h\nu - E_g)^n$$

where α is the absorption coefficient, n=1/2 or 2 direct or indirect allowed transition, C is the characteristic parameter for respective transitions, hν is the photon energy, and $E_g$ is the bandgap energy. Plots for CdZnS and Lawsonia inermis added CdZnS nanoparticle is shown in figure 3.

From the figure, the energy bandgap of Lawsonia inermis added CdZnS nanoparticles are found to be decreased than the pure CdZnS nanoparticles.

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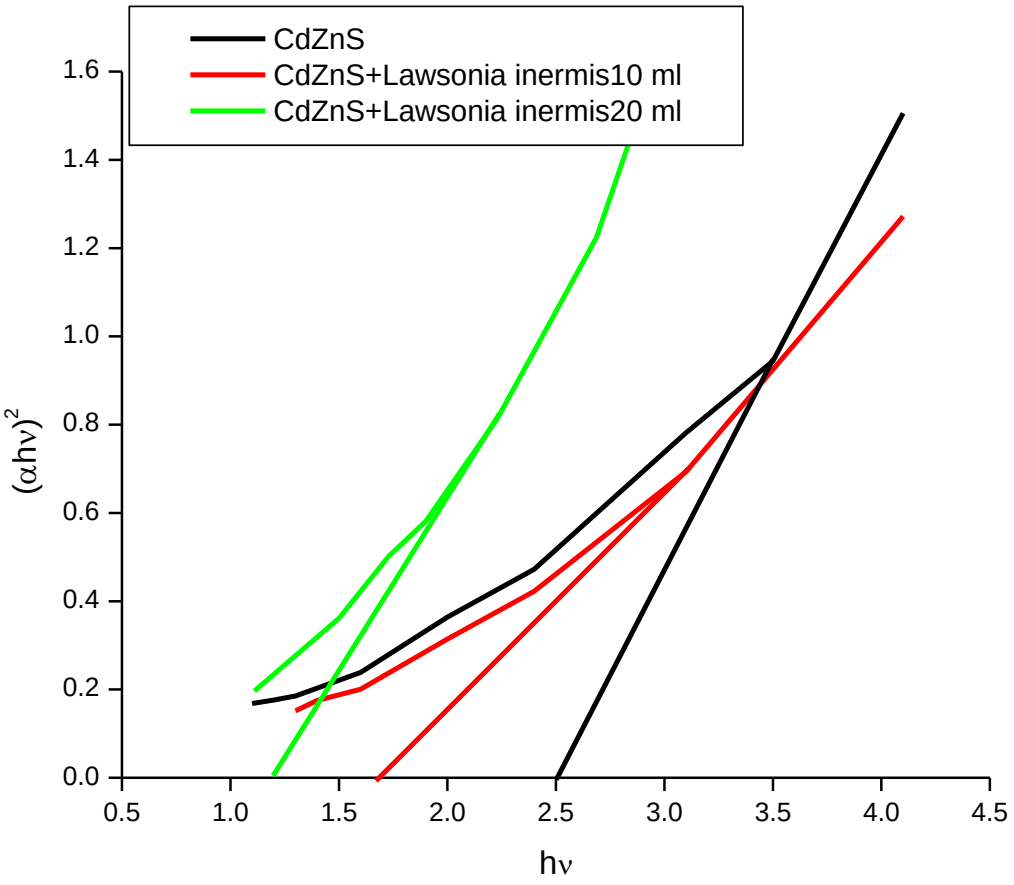


**Figure 3.Plot for bandgap energy of CdZnS nanoparticles and Lawsonia inermis (10 ml and 20 ml) added CdZnS**

3. Morphological studies

The morphology of CdZnS nanoparticles and Lawsonia inermis added nanoparticles was studied using a scanning electron microscope (SEM). The SEM images show the randomly distributed CdZnS nanoparticles with a quasi-spherical shape.

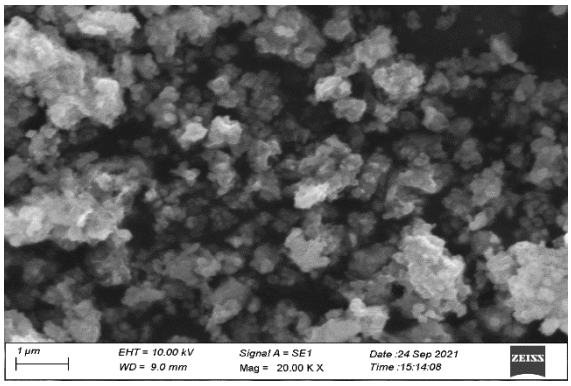


**Figure 4(a)**

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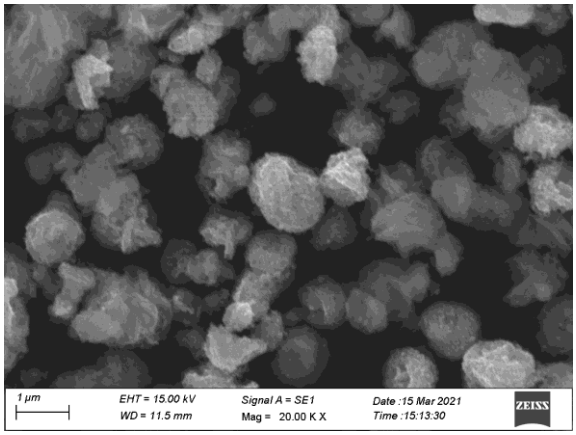


**figure 4(b)**

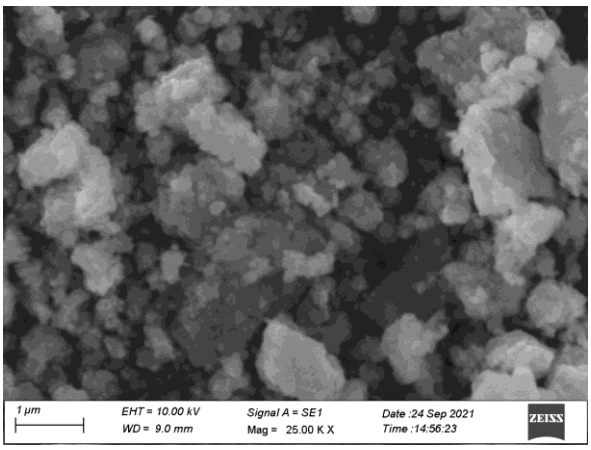


**Figure 4(c)**

**Figure 4 a,b,c SEM images for CdZnS, Lawsonia inermis (10 ml, 20 ml) added CdZnS**

## 4. Elemental analysis

The EDAX spectrum was used to confirm the elemental compositions of CdZnS and Lawsonia Inermis added CdZnS nanoparticles. The peaks obtained from the spectrums for CdZnS and Lawsonia inermis (10 ml,20 ml) added CdZnS nanoparticles are shown in figure 5.a,b,c respectively, shows the presence of major elements Cadmium, Zinc and Sulphur in the figure and the presence of carbon, nitrogen and oxygen in figures confirms the presence of Lawsonia inermis with CdZnS nanoparticles. The elemental composition analysis for CdZnS and Lawsonia inermis 10ml, 20ml added to CdZnS nanoparticles are shown table 1 a,b, c respectively.

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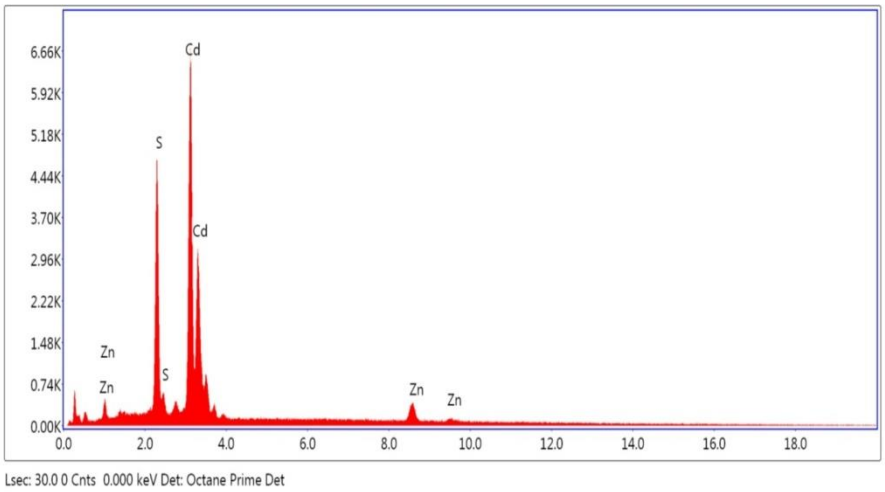


**Figure 5 a EDAX spectrum of CdZnS nanoparticles**

| Element | Weight% of CdZnS | Atomic % |
|---|---|---|
| Cd | 70.60 | 46.12 |
| Zn | 11.53 | 12.95 |
| S | 17.88 | 40.94 |

**Table 1.a EDAX elemental analysis of CdZnS nanoparticles**

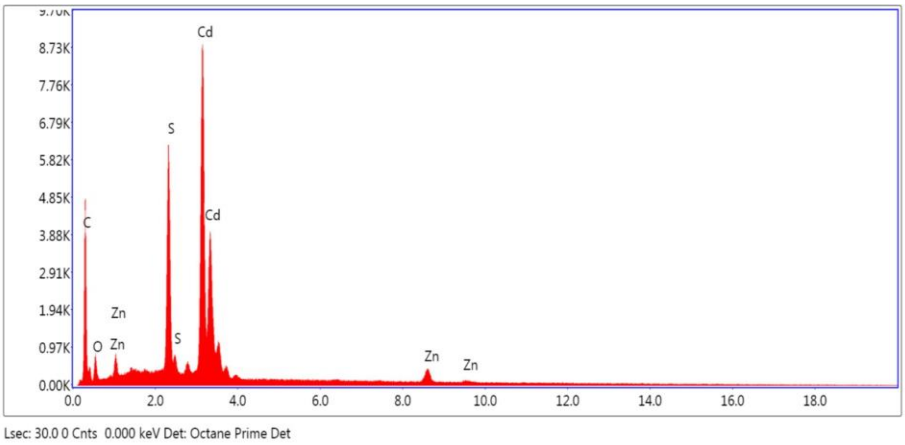


**Figure 5 b EDAX spectrum Lawsonia inermis (10 ml) added CdZnS nanoparticles**

| Element | Weight% | Atomic% |
|---|---|---|
| C | 9.60 | 35.40 |
| N | 0.98 | 3.10 |
| O | 4.08 | 11.28 |
| Cd | 61.59 | 24.26 |
| Zn | 9.69 | 6.56 |
| S | 14.06 | 19.41 |

**Table 1.b EDAX elemental analysis of Lawsonia inermis (10 ml) added CdZnS nanoparticles**

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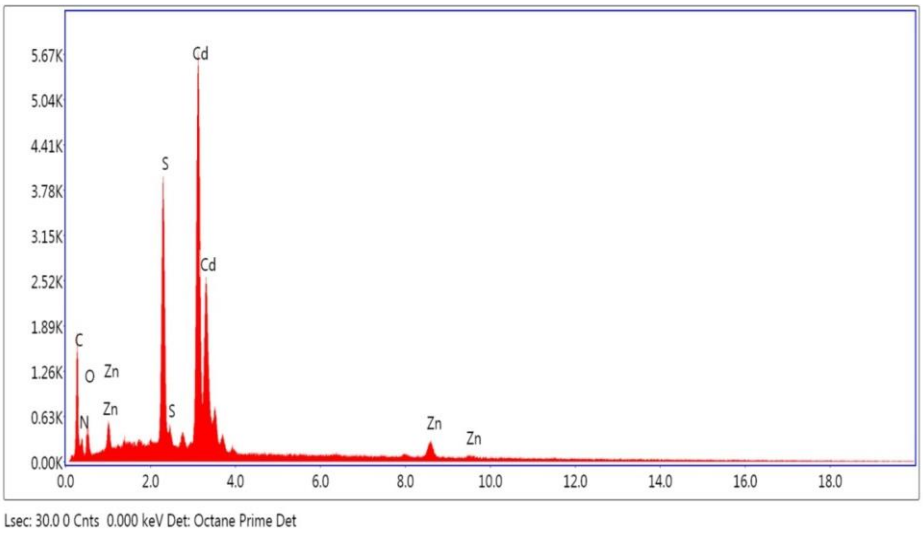


**Figure 5 c EDAX spectrum Lawsonia inermis (20 ml) added CdZnS nanoparticles**

| Element | Weight% | Atomic% |
|---|---|---|
| C | 24.27 | 56.03 |
| N | 2.00 | 3.97 |
| O | 9.24 | 16.02 |
| Cd | 46.82 | 11.55 |
| Zn | 6.50 | 2.76 |
| S | 11.17 | 9.66 |

**Table 1.c EDAX elemental analysis of Lawsonia inermis (20 ml) added CdZnS nanoparticles**

## Conclusion

CdZnS:Lawsonia Inermis with two different concentrations (10ml amd 20 ml) were prepared using chemical precipitation method. The structural and morphological properties of CdZnS and CdZnS with Lawsonia Inermis NPs, were investigated. Study (XRD) on the structural properties showed that CdZnS and Lawsonia Inermis: CdZnS NPs have cubic (zinc blende) structure and the particle size of CdZnS NPs added with Lawsonia Inermis becomes greater than CdZnS NPs. The optical properties of CdZnS nanoparticles and Lawsonia inermis added CdZnS nanoparticles were investigated. The absorption edge is found to shift towards a higher wavelength (red shift) ie the bandgap decreases as the particle size increases. The bandgap energy of the prepared samples was calculated using the Tauc relation, the energy bandgap of Lawsonia inermis added CdZnS nanoparticles are found to be decreased than the pure CdZnS nanoparticles. SEM study confirms the particle size and the morphology of the prepared nanoparticles. EDAX spectra reveals the presence of major chemical element.

## References

[1]Deepa Tyagi, Pankaj Chhabra, Evaluation of Mehndi Leaves Extracted Dyed Fabric, Journal Global Values, Vol. X, No.I, Article No. 6, pp.48 -59.

[2]. Energy Band Gap Studies of CdS nanomaterials, D. Patidar, K.S. Rathore, N.S. Saxena, Kananbala Sharma and T.P. Sharma, Journal of Nano Research Vol.3 (2008), 97-102.
[3] Sabit Horoz, Orhan Baytar, Omer Sahin, Hilal Kilicvuram, Photocatalytic degradation of methylene blue with Co alloyed CdZnS nanoparticles, Journal of Material Science; material electronics, 2017.
[4]J K. Salem, T M Hammad, S Kuhn, M A Draaz, N.K Hejazy, R. Hempelman, Structural and optical properties of Co-doped ZnS nanoparticles synthesized by a capping agent. Journal of Material Science; material electronics, 2177-2182 (2014)
[5] R. Dang, X Ma, CdS nanoparticles decorated anatese $TiO_2$ nanofibres with enhanced visible light photocatalyst activity for dye degradation , Journal of Material Science; material electronics, 8818-8823, 2017.
[6] C. Xing, Y. Zhang, W.Yan, L.Guo, Band structure-controlled solid solution of Cd1-ZnxS photocatalyst for hydrogen production by water splitting. International Journal of Hydrogen energy, 2018-2024, 2006
[7] C Acar, I. Dincer, C. Zaimfirescu, A review on selected heterogeneous photocatalysis for hydrogen production, International Journal of Energy Research, 1903-1920, 2014
[8] Hrishikesh Upadhyaya, Soumitra Shome, Rajdeep Sarma, Sujit Tewari, Mrinal Kanti Bhattacharya, Sanjib Kumar Panda, Green Synthesis, Characterization and Antibacterial Activity of ZnO Nanoparticles. American Journal of Plant Sciences, 1279-1291, 2018.
[9] Jalal, R., Goharshadi, E.K., Abareshi, M., Moosavi, M., Yousefi, A. and Nancarrow, P. ZnO Nanofluids: Green Synthesis, Characterization, and Antibacterial Activity. Materials Chemistry and Physics, 121, 198-201, 2010.
[10] Sathya, A. and Ambikapathy, V, Studies on the Phytochemistry, Antimicrobial Activity and Green Synthesis of Nanoparticles using Cassiatora L. Drug Invent Today, 4, 408-410, 2012
[11] Hudlikar, M., Joglekar, S., Dhaygude, M. and Kodam, K. Latex-Mediated Synthesis of ZnS Nanoparticles: Green Synthesis Approach. Journal of Nanoparticle Research, 14, 1-6, 2012
[12] Hussain, I., Singh, N.B., Singh, A., Singh, H. and Singh, S.C, Green Synthesis of Nanoparticles and Its Potential Application. Biotechnology Letters, 38, 545-560, 2016
[13] Balasooriya, E.R., Jayasinghe, C.D., Jayawardena, U.A., Ruwanthika, R.W.D., Mendis de Silva, R. and Udagama, P.V. Honey Mediated Green Synthesis of Nanoparticles: New Era of Safe Nanotechnology. Journal of Nanomaterials, 2017, 1-10.
[14] Habbal, O., Hasson, S.S., El-Hag, A.H., Al-Mahrooqi, Z., Al-Hashmi, N., Al-Bimani, Z., Al-Balushi, M.S. and Al-Jabri, A.A. Antibacterial Activity of Lawsonia i nermis Linn (Lawsonia inermis ) against Pseudomonas aeruginosa. Asian Pacific Journal of Tropical Biomedicine, 1, 173-176, 2011
[15] Kannahi, M. and Vinotha, K. Antimicrobial Activity of Lawsonia inermis Leaf Extracts against Some Human Pathogens. International Journal of Current Microbiology and Applied Sciences, 2, 342-349, 2013.