Cadmium Sulphide Nano Particles Doped With Ni And Its Antimicrobial Study

Pritisha Dakuwa, S.bardaloi

Abstract : CdS:Ni nano particles are synthesized by chemical bath deposition method grown into Ammonia at room temperature. The formation of nano particles are confirmed and calculated by XRD analysis. Different instrumentation techniques XRD, TEM, SEM etc. are employed to investigate structural properties of CdS:Ni. Crystallite size is found to be approximately 5.1nm from XRD analysis. The particle size is calculated from TEM study is found to be approximately 5.6 nm. SEM analysis are performed to study the morphological studies of CdS:Ni nano particles. Optical studies are performed with different instrumentation technique UV-VIS, PL analysis etc. Absorption peaks from UV-VIS analysis is found to be approximately 410.2 nm. The peak of photoluminescence is found at 493.6nm for Ni doped CdS nano particles. The antimicrobial studies are observed against two different strain Escherichia coli E.coli and Staphylococcus aureus (S.Aureus) and found affective towards these strains.

Keywords: Chemical Bath Deposition, EDAX, Nanoparticle, PL, SEM, TEM, UV, XRD

1. INTRODUCTION

Nanoscale materials play very important role in recent times. It had been a great scope of interest from the past decades. Being large surface area to volume ratio of nano materials, they show different physical and chemical properties than the bulk material. II-VI semiconductor nanomaterial has of great importance due to their unique properties. Among them CdS nano particles have attracted much attention due to its suitable unique optical, electrical properties than that of bulk materials. CdS is a very promising stable material and very cost effective with band gap of about 2.42eV at room temperature. It has been widely used in many applications of nano electronics such as photovoltaic cells [1], photo catalysis [2], solar cells [3-5] , photo detectors [6] etc. When CdS is doped with Cu and Ni, its electrical, optical, properties change. Doping also increases conductivity. There are many techniques for the synthesis of CdS:Ni nanoparticles such as Chemical precipitation method [7], chemical bath deposition method [8], microwave heating process [9], solvothermal method [10], hydrothermal method [11] etc. Here chemical bath deposition method has been employed for the synthesis. The advantage over employing CBD method is that this method is very simple and inexpensive. The CBD can be performed without using any sophisticated instrument at room temperature. To study the antimicrobial properties of CdS:Ni, they are injected against two strain Staphylococcus Aureus (S.aureus) and Escherichia coli (E.coli) which are gram positive and gram negative respectively. Both these two strains are pathogenic to human body. During antimicrobial study, CdS:Ni show effective resistance towards these pathogens.

2 MATERIALS AND METHODS

For synthesis of CdS:Ni, CdS solution is prepared using cadmium chloride ($CdCl_2$) and sodium sulphide flakes ($Na_2S{\times}H_2O$). Liquor ammonia (NH_3) is added drop wise to the mixed solution. For preparation of Ni doped CdS, Nickel Chloride Hexahydrate ($NiCl_2.6H_2O$) is used for the source of Ni.

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Wt percentage of CdS solution is prepared by adding distilled water to cadmium chloride and sodium sulphide flakes separately and stirred for 2 hour for complete dissolution. Liquor Ammonia is added drop wise to the solution and stirred continuously for four hour at room temperature. The prepared solution is kept overnight for complete dissolution and thus CdS solution is ready for analysis. Ni solution (5%) is prepared separately and added drop wise to the main solution of CdS. The whole solution is stirred for four hour for complete dissolution at room temperature. Thus Ni doped solution is prepared and kept for 24 hour. After complete dissolution, the solution is filtered, washed with distilled water and dried. Thus Ni doped CdS sample is prepared

3 RESULTS AND DISCUSSION

3.1 XRD study.

XRD analysis is performed with the help of Philps X'pert Pro diffractometer. The operating voltage of the diffractometer is 40kV and current is 35mA. The XRD pattern of CdS:Ni are shown in figure1. The peaks are positioned with 2θ values 27.00, 44.42 and 52.56 which corresponds to the miller indices for the crystal plane of reflection (111), (220) and (311). The position of peaks along with planes show face centered cubic phase as compared with standard reference data (JCPDS Powder Diffraction File (PDF No- 890440). To determine the particle size, Debye Scherrer formula is used. The formula is given as below,

$$D=k\lambda/\beta\cos\theta \quad (1)$$

Where, k is a dimensionless constant, λ is the wavelength of X-Ray used, β= Full width at Half maxima (FWHM) of the diffraction peak and θ is the diffraction angle for the (hkl) plane (Bragg's angle). It is observed from the fig.1 that all the three planes shift to larger angle with increase in doping percentage of Ni^{2+}. Because the ionic radius of Ni (.69 Å) is less than Cd (0.96Å). Therefore, dopant Ni^{2+} has not been able to affect the structure of host crystal CdS and 2θ angle peaks are slightly shifted The small shift in XRD peaks indicates the presence of dopant (Ni) in doped CdS nano particles [12]. The average particle size is calculated from the XRD diffraction using Debye Scherrer's formula is 5.1nm which is less than Bohr's radius (10.4 nm). Hence, Ni doped CdS nano particles have great advantage in semiconductor nano particles due to particle size variations in doping.

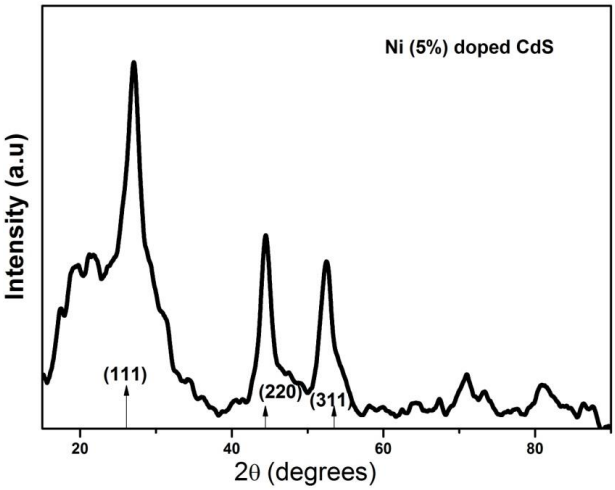

Fig1. *XRD pattern of CdS:Ni*

3.2 TEM Study

TEM pictures of Ni doped CdS is shown in fig.2. For analysis of TEM study, TEM (JEOL-100 CX) is employed for CdS:Ni nano particles. The particle size from the TEM studies is found to be approximately 5.6nm. SAED pattern of CdS:Ni is shown in fig 3. Three planes (111), (220) and (311) shows cubic structure of CdS:Ni which consistent with XRD results

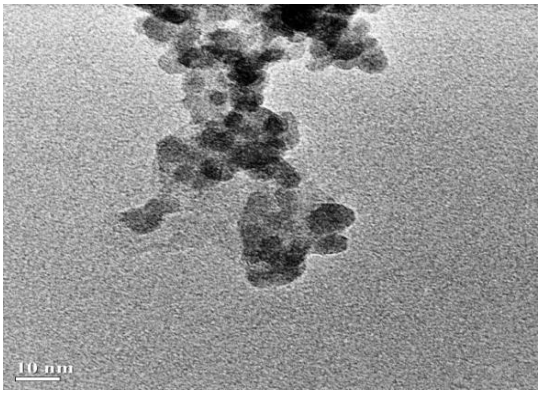

Fig.2 *TEM image of CdS:Ni*

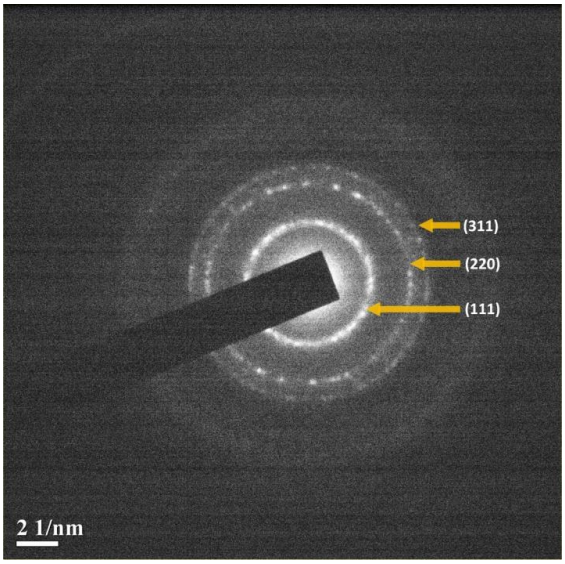

Fig3. *SAED pattern of CdS:Ni*

3.3 FESEM and EDAX analysis

For morphological studies of CdS:Ni, SEM analysis is performed with the help of FESEM (SIGMA 300) as shown in fig.4. Nano Particles are uniformly distributed over the large surface area. Nano particles have been observed to have spherical symmetry, with agglomerating everywhere. The average particle sizes are found to be approximately 29nm for Ni doped CdS nanoparticles. The EDAX spectrum of Ni doped CdS is shown in fig.5. Except Cd, S and Ni, no other impurities are present in CdS:Ni as it can be seen from the table. The concentration of Ni/Cd matched with our experimental value and found to be nearly equal to our stoichiometry

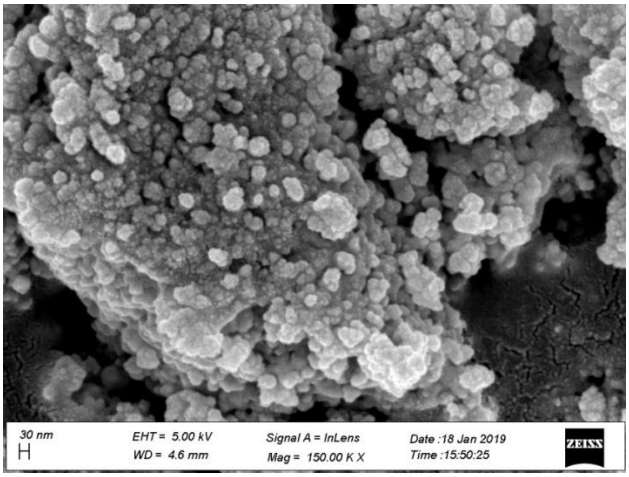

Fig.4 *SEM image of CdS:Ni*

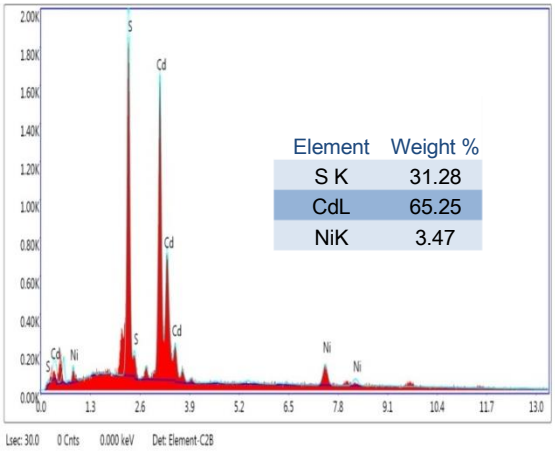

Fig.5 *EDAX of CdS:Ni*

3.4 Optical Absorption Study

Optical properties of Ni doped CdS nano particles are investigated with the help of UV- Visible absorption spectrometer (Shimadzu UV-2600) at room temperature as shown in fig.6. The absorption peaks is found at 410.2nm. The band gap value is calculated using Tauc's relation by the following equation,

$$(\alpha h\nu)^2 = k(h\nu - Eg) \quad (3)$$

Here, hν is the photon energy, Eg is the optical band gap, K is a constant and α is the absorption coefficient. The optical band gap of Ni doped CdS is found to be 2.75eV as shown in fig.6. which revealed that the band gap of Ni doped CdS is more

than CdS nanoparticles. Hence blue shift of light occurs with band edge value of 0.33eV. The band gap values are obtained from hν vs $(\alpha h\nu)^2$ as shown in fig. 7. Therefore Ni doped CdS has more advantage over pristine CdS because of band gap variations and it can be used in optoelectronics devices like solar cells and semiconductor devices.

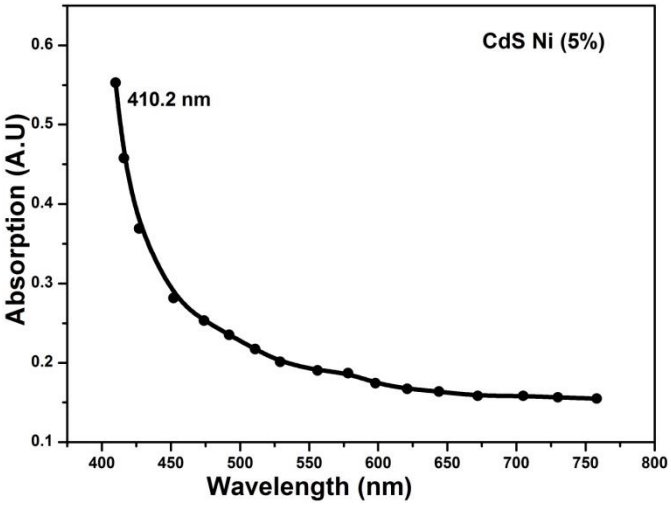

Fig.6 *UV-VIS of CdS:Ni*

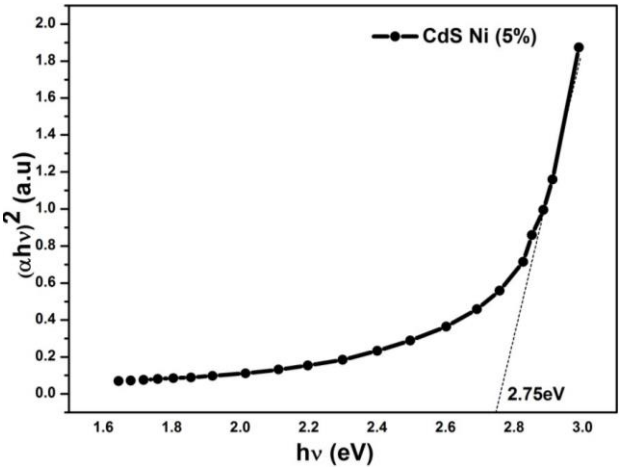

Fig.7 *Band gap of CdS:Ni*

3.5 Photoluminescence Study

The photoluminescence properties of CdS:Ni is studied with the help of Fluorescence Jasco Specfluorometer (FP-8300) in the range of 200 – 600nm. The PL intensity is found at 493.6nm as shown in fig.8. In Ni doped CdS nanoparticles, it is observed that, the emission peak is very sharp and there is no other peak found. Sharp peaks are called exciton peak [13]. Hence green emission band has been observed

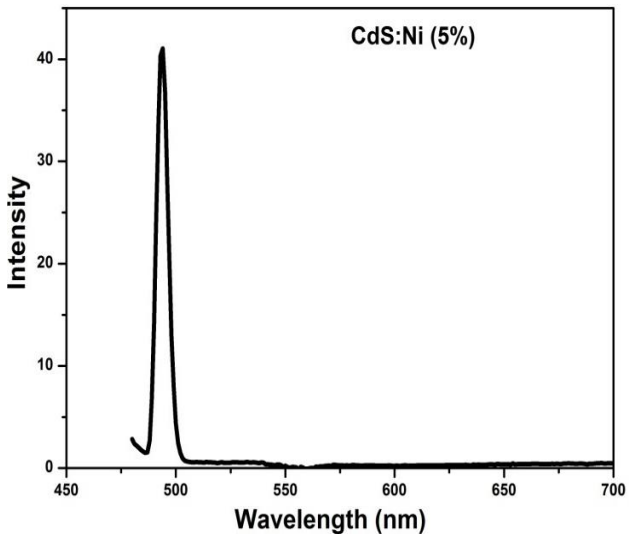

Fig.8 *PL analysis of CdS:Ni*

4 ANTIMICROBIAL STUDY

4.1 Preparation of Culture Media and Microbial Culture

For antimicrobial study of Ni doped CdS, the two strain Escherichia coli (E.coli) and Staphylococcus aureus (S.aureus) which are gram negative and gram positive, are cultured and maintained at laboratory. Nutrient broth is prepared to grow the strain at 39^0C. For antibacterial susceptibility test 0.5 McFarland' turbidity standard was used during the experiment.

Well diffusion method is employed for injecting the sample. Two different slides are prepared against two strains. Wells are made with different concentrations of 30ml and 50ml respectively. S.aureus and E.coli which are gram positive and gram negative bacteria are prepared for the experiment as shown in fig.9. It is observed from the figure that zone of inhibition (ZOI) is created which indicate that CdS:Ni has resistance towards these strain. The value of ZOI is given in table1. The experiment shows that CdS:Ni is effective towards the strain E.coli and S.aureous and it depends on the concentration of the nanoparticles. With increase in concentrations, the sample could have showed more resistivity towards the strains and large zone will be created i.e higher concentrations of sample can destroy the bacteria at a faster rate [14]. Therefore it can be proved that CdS:Ni nanoparticles is very effective to destroy bacteria with higher concentrations. Fig shows that CdS:Ni has more affect towards E.coli compared to S.aureous, infact the sample does not show any activity at 30mg. 50mg, and 100mg. It has been expected that if concentration increases beyond 100mg, CdS also could have show antibacterial activity towards S.aureus. The minimum inhibitory concentration (MIC) was found at 0.4mm for CdS:Ni nano particles. Therefore, antibacterial properties has been studied for CdS:Ni nano particles and found effective towards these strains. To get more effective result for microbial test, the concentration of nano particles should increase and can perform better activity result.

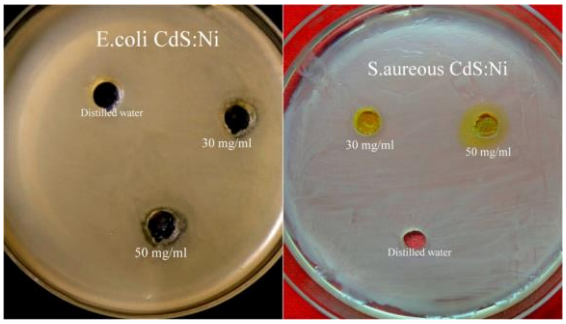

Fig.9 *Antimicrobial study of CdS:Ni*

Table1. Table of ZOI

Strain	Sample	ZOI (mm)	
		30mg/ml	*50mg/ml*
E.coli	CdS:Ni	3	5
S.Aureus	CdS:Ni	-	-

5. CONCLUSION

CdS:Ni has been synthesized by chemical bath deposition method. Structural, optical as well as antimicrobial properties are studied. Structural properties are characterized by some instrumentation technique XRD, TEM, SEM etc. The particle size is obtained from XRD analysis is 5.1nm. Particle size from TEM analysis of CdS:Ni is found to be 5.6nm. Also, strain and crystallite size is calculated from W-h plot. UV absorption spectrum is found at 410.2nm. Band gap is found to be approximately 2.75eV. PL analysis shows the intensity peak of CdS:Ni is at 493.6nm. The antimicrobial properties of CdS:Ni is examined in the laboratory and found effective against two given strains E.coli and S.aureous which are pathogenic.Thus doping of CdS with Ni has significant advantage.

ACKNOWLEDGMENT

The authors are thankful to SAIF, Dept. of Instrumentation & USIC, Gauhati University for providing XRD facilities, IASST, Boragaon, Guwahati for providing UV-VIS, PL analysis and antimicrobial laboratory, SAIF NEHU for providing TEM analysis, SAIF, Dept. of Chemistry, Gauhati University for providing SEM and EDAX analysis.

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