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Mn^{2+}-Doped with ZnS Nanoparticle Synthesized by Chemical Co-Precipitation Technique

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***Abstract:** Manganese (Mn^{2+}) ions doped with Zinc sulfide (ZnS) nanoparticles are synthesized by chemical co-precipitation technique. The samples characterized by physical, optical and magnetic properties. XRD results show the 2θ peaks that appear due to reflections from the (100), (002) and (101) cubic crystal planes of ZnS and distinguished to be hexagonal wurtzite structure. At 700°C, ZnS is changed over into ZnO stage due to oxidation reaction. The photoluminescence range of nanoparticles appears as wide glow in green visible region that shows the possibility of creating photonic gadgets. The calculated bandgap (E_g) values is 2.3951 eV. Magnetic hysteresis study of magnetic field (B) indicate the material has good magnetic property similar to intensity magnetization permeability.*

***Keywords:** Hysteresis Curve; XRD; Magnetic properties*

I. INTRODUCTION

In present eras there has been broad interest in studies on luminescent property of inorganic nanocrystals semiconductor. One of the interesting properties of these are called quantum dots obtained due to quantum confinement that happens when metal and semiconductor particles get reduced compared to exciton Bohr radii. The increment of energy band gap decreases the size for semiconductor nanocrystals. By decreasing the size, the absorption and emission spectra are observed to shifts to maximum higher energy. The excitation peaks in the absorption range, results in a tunable fluorophore that can be energized effectively at any wavelength shorter than the emission peak however they emit with the same characteristic property as thin, symmetric spectrum irrespective of the excited wavelength. In the undoped II–VI group of semiconductor elements viz., CdS, ZnS, and CdSe, the Energy band is controlled through engineering the crystal measure which leads to various tunable band-edge emission **[1–5]**. Beaulac et.al **[6]**, has detailed the nanocrystals doped with semiconductor have modern property of luminescent material. Both ZnS and Mn-doped ZnS retain 1D nanostructures by its unique physical and chemical properties with wide range of applications within the field of cathode beams, TFT displays, lasers and sensors, have been reported **[7–11].** The Mn^{2+} particle that are utilized as a dopant in various luminescent materials have d^5 electron configuration.

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The Mn^{2+}nanoparticle illustrates the wide peak emitted and its position depends intensely over the host of lattice point by its variation in the field strength of crystal present within the host matrix. A huge assortment of potential application is utilized when the two-component particles; in case when the center core and outer shell gives a combination of ferromagnetic and antiferromagnetic property **[12, 13].** It is observed with shift of hysteresis loop during demagnetization. The elucidation of predicted results may be much complicated owed to combined impacts and interactions with the implanting medium.Within the current work structural, optical and magnetic studies over isolated nanoparticles of the Mn^{2+} -doped ZnS nanoparticles with their attractive properties of the ensembles were also performed.

II. EXPERIMENTAL TECHNIQUE

Mn^{2+}-doped ZnS Nanoparticles were synthesized using chemical co-precipitation technique. The chemical substances used in preparation of sample were of high purity and substances were completely utilized without any other assist refinement. Nanoparticles were synthesized by dropping concurrently 50ml of 0.4M zinc sulphate (ZnS) solution along with 50ml of 0.1M manganese sulphate (Mn^{2+}) solution and 50ml of 0.5M sodium sulphide solution into 50ml of sanitized water with 50ml of 0.1M solution of EDTA. The solution was mixed vigorously with a magnetic pellet stirrer at room temperature. The important of adding EDTA is to stabilize nano particles against accumulation that lead to increment of particle size. The precipitate is isolated from the stirred mixture with several washing of purified water, later alcohol is added to expel the impurities in the samples, including initial reactants and the traces of EDTA. The damp precipitate obtained were dried and completely extracted to ground. Finally, the sample ware prepared and to analysis the different characterization techniques.

III. RESULTS AND DISCUSSION

The prepared samples are characterized by morphological, functional, structural, thermal, and electrical studies and reported.

A. XRD Analysis

X-ray diffraction patterns of the synthesized $ZnSO_4$:Mn nanoparticle were analyzed carefully by an X-ray diffractometer with standard wavelength of CuKα radiation (λ=1.54Å) to identify the nature of crystalline samples.

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Figure 1 shows the Mn^{2+}-doped ZnS peaks at 2θ = 32 º, 34º, 36º,47 º, 56 º, 63 º, and 69 º which confirm the semi-crystalline nature of the sample. The sharp peaks (100), (002) and (101) appear due to reflections of cubic crystalline planes of ZnS nano phase. All patterns observed for diffracted peaks in ZnO nanoparticles were identified as hexagonal wurtzite structure.
here, X-ray wavelength (λ = 1.5406 Å), shape constant (k ~ 0.89), average diameter of particle (D), half-height line broadening in radian (β) and = Bragg's angle(θ). The average Grain size (D) value for the present sample were 38.013 nm. It noted when the temperature reaches 700°C, the ZnS is completely get oxidized into ZnO at surrounding atmospheric condition [14].

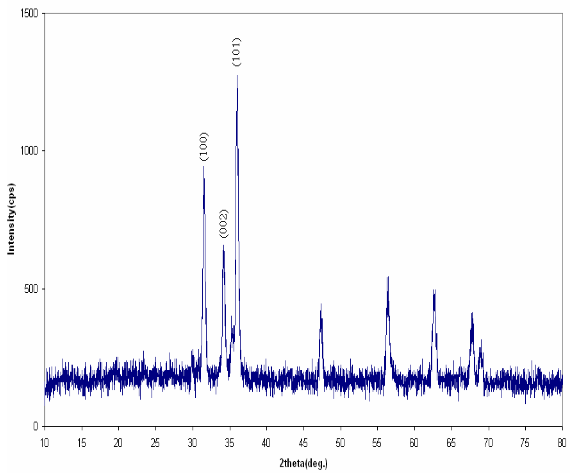
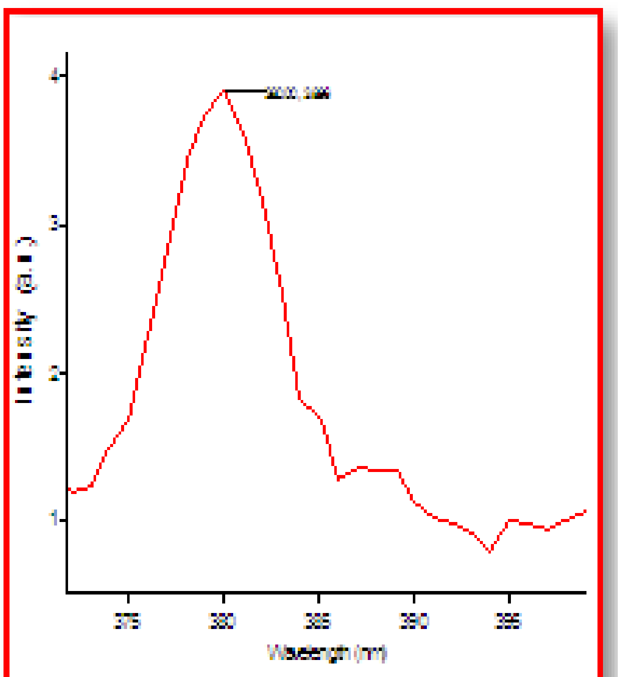


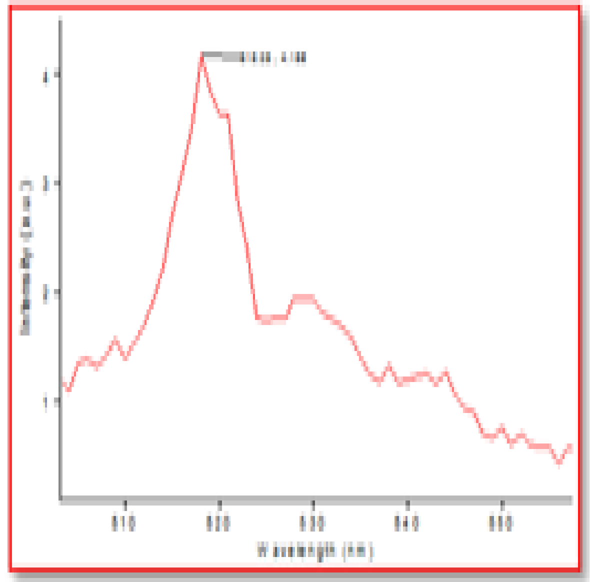
Fig.1 XRD pattern on ZnSO4:Mn nanoparticle



(a)

The estimate of nano crystalline particle size of the Mn^{2+}-doped ZnS is assessed utilizing Scherrer's equation (1):

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



(b)

Fig. 2 Photoluminescence spectrum of (a) ZnSO4 : Mn [Exc=380nm] and (b) ZnSO4 : Mn [Em=518nm] nanoparticles

A. Photoluminescence

The PL (Photo luminescence) spectrum of the Mn2+-doped ZnS nanoparticle were recorded at ambient temperature (30°C) utilizing spectroflurometer– 67(FP-6500). Fig. 2(a, b) show the excitation of ZnSO4 : Mn [380nm] and emission of ZnSO4 : Mn [518nm] nanoparticles. It is observed that the highest sharpest peak of absorption for synthesized sample appears at 300 nm clearly and from the absorption edge of the bulk ZnS (380) it specifies the blue shift and is visibly depicted in the Fig. 2a. ZnS has absorption wavelength of light within 220-380 nm and electron from ground state goes to exited state at 380 nm [15]. Fig.2b reveals the come back to n2 state where emission occurs at 518.05 nm and this appears at visible region. Semiconductor nano crystallite materials in this range shows an 3D confinement quantum measure effect in the electronic structure. The lifetimes for Mn2+ emission in ZnS nanoparticles have been measured. The impact of dopant concentration on the luminescence proficiency has been examined and detailed, but the reasons for their extinguishing are still indistinct.

B. Magnetic Property Analysis

Magnetic Properties of nanocrystalline ZnSO4:Mn powders recorded through Hysteresis loop tracer. The magnetic field values observed in the range of 100-350 Gauss.

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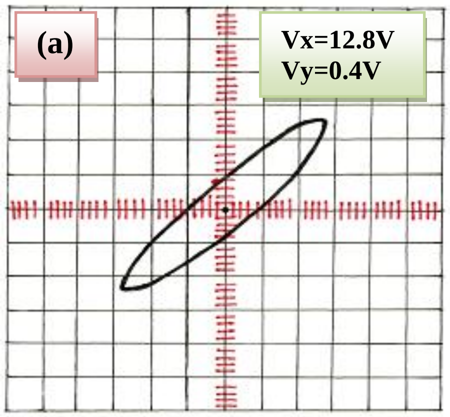
The calculated values for area of the loop are 317 mm (B=324 G) and 737 mm (247 G) are shown in the Fig 3. It was found that when magnetic field increases the area of loop decreases [12, 13].

For Magnetic Field = 247 G



For Magnetic Field = 324 G

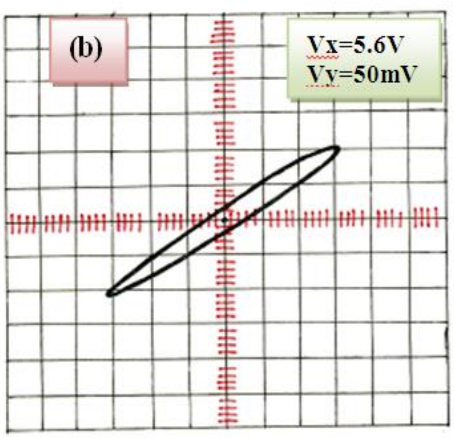


Fig. 3 Magnetic properties of (a) $ZnSO_4$: Mn (B=324G) and (b) $ZnSO_4$: Mn [B=247G] nanoparticles

IV. CONCLUSION

Chemical co-precipitation technique was utilized to synthesize Mn^{2+} doped ZnS nanoparticles. The structure, optical, magnetic properties of the samples were analyzed using XRD, PL-spectra and magnetic hysteresis curve. XRD analysis indicates that the sample prepared were in hexagonal phase. PL spectra reveal that the sample has optical band gap energy of (E_g) 2.3951 eV. Magnetic hysteresis studies of magnetic field (B) indicate the material has good magnetic property like intensity magnetization permeability. The calculated values for area of the loop are 317 mm (B=324 G) and 737 mm (247 G). It was found that when magnetic field increases the area of loop decreases.

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