

CR: ZNS – FROM SYNTHESIS TO APPLICATION: A REVIEW

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Abstract: In this paper, we report synthesis, characterization and practical application of nanocrystalline chromium (Cr) doped Zinc sulphide (ZnS) nanoparticle, which have been synthesized by chemical co-precipitation method. The structural properties of Cr: ZnS nanoparticles have been characterized by X-ray diffraction (XRD) analysis. The XRD patterns show cubic structure in nanoparticles. It is found that increase in molar concentration of (Cr) as doping agent increases the particle size. Absorption spectra, electrical properties and functional group identification, energy band gap, thickness have been obtained using UV-Vis spectrophotometer; The obtained values of band gap have been founded to be in the semiconductor range i.e. 3.1 to 4.5 eV. FTIR determines the molecular structure and assignment of the spectra. It was also found that on increasing molar concentration of doping agent optical band gap (Eg) increases due to quantization effect. Using EDS, percentage of chemical compositions and purity of sample is obtained.

Keywords: Cr: ZnS, Chemical co-precipitation, functional group, energy band gap, EDS, UV-visible spectroscopy, XRD, FTIR.

I. INTRODUCTION

During the past two decades, the “small-particle” research has become quite popular in various fields of science and technology. The “small-particles” now we call nanostructured materials are very interesting materials both for scientific reason and practical application. Semiconductor nanocrystals represent a class of materials that have interesting optical and electrical properties by controlling their band gaps. They have attracted much attention over the past few years because of their novel properties originating from quantum confinement effect. [1] In the case of semiconductor nanoparticles, radiative or nonradiative recombination of an exciton at the surface states becomes dominant in its optical properties with a decrease of particle size. Therefore, the decay of an exciton at the surface states will influence the qualities of the material for an optoelectronic device. These size dependent optical properties have many potential applications in the areas of solar energy conversion, light emitting devices, chemical/biological sensors and photo catalysis. Wide band gap II–VI semiconductors are expected to be the novel materials for the optoelectronic devices. ZnS has been used widely as important materials for photoluminescence (PL), electroluminescence (EL) and cathodoluminescence (CL) devices due to its better chemical stability compared to other chalcogenides such as ZnSe. In optoelectronics, it finds use as light emitting diode, reflector, dielectric filter, window material photo detectors and optical sensors. Nevertheless the

theoretical and experimental researches on Cr doped ZnS are still limited [2]. Keeping in view the above discussion, In the present paper an effort has been made to study the synthesis, structural, electrical and optical properties of Cr:ZnS nanoparticles of different molar concentration of Cr(NO₃)₂ as doping agent and poly(vinyl alcohol) [CH₂CH(OH)]_n as capping agent. The main purpose of this paper is to study the effect of Cr doping on structural and optical properties of Cr: ZnS nanocrystal and applications of the nanocrystal. Nanocrystal synthesized by co precipitation method and its practical application.

EXPERIMENTAL PROCEDURE

Some Synthesis method for nanomaterials:-

Table.1 Some Synthesis method for nanomaterials.

Synthesis method	Synthesis	Reaction Temp. [°C]	Reaction period	Solvent	Surface-capping agents	Shape control
co-precipitation	very simple, ambient conditions	20–90	minutes	water	needed, added during or after reaction	not good
organic compound	complicated, inert atmosphere	100–320	hours–days	organic compound	needed, added during or after reaction	very good
micro emulsion	complicated, ambient conditions	20–50	hours	organic compound	needed, added during or after reaction	Good
hydrothermal synthesis	simple, high pressure	220	hours ca. days	water-ethanol	needed, added during or after reaction	very good

Material and method

Zinc chloride (ZnCl₂), sodium sulfide (Na₂S) and chromium (III) nitrate Cr(NO₃)₂ as starting materials poly(vinyl alcohol) [CH₂CH(OH)]_n as a capping agent for control particles size and double-distilled water as dispersing solvent were used to prepare Cr: ZnS nanoparticles. The Cr: ZnS nanoparticles were prepared by the chemical co-precipitation method. First, ZnCl₂ was dissolved in double-distilled water with 0.1 molar concentrations and then obtained molar solution was stirred for 20 min at room temperature to achieve complete dissolution. Sodium sulfide and chromium chloride was also dissolved in double-distilled water separately as per molar concentration. Afterwards, first sodium sulfide solution was added drop by drop to the zinc chloride solution. Next the chromium chloride solution with desired molar concentration was added to this solution. Then, an appropriate amount of poly (vinyl alcohol) [CH₂CH (OH)]_n (0.1 M) was added to the reaction medium to control the particle size of Cr :ZnS. The resulting solution was stirred continuously for 4 h. In the final step, the sky blue obtained precipitate was filtered and dried at 60 oC temperature to remove both water and organic capping and other by products formed during synthesis. After sufficient

drying, the precipitate was crushed to fine powder with the help of mortar and pestle [3]. It is necessary to mention that different sample of nanoparticles has been obtained by changing the molar concentration of doping agent.

Characterization technique:-

1.1 XRD - Analysis: - X-ray diffractometer consist of three basic elements: an X-ray tube, a sample holder, and an X-ray detector. For typical powder patterns, data is collected at 2θ from $\sim 5^\circ$ to 70° , angles that are preset in the X-ray scan.

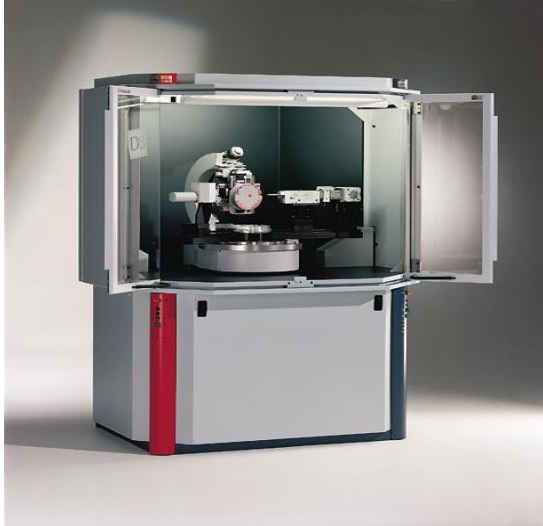


Fig. 1 Bruker's X-ray Diffraction D8-Discover instrument.

1.2 Applications of XRD.

X-ray powder diffraction is most widely used for the identification of unknown crystalline materials (e.g. minerals, inorganic compounds). Determination of unknown solids is critical to studies in geology, environmental science, material science, engineering and biology.

1.3 XRD determines the following information of sample.

1. XRD measure the average spacing between layers or rows of atoms i.e. 'd'.
2. Orientation of a single crystal or grain size is calculated by 'scherrer equation'.
3. Crystal structure of the material sample is determined.
4. Size, shape and internal stress of crystalline region is also determined by XRD.
5. A detailed picture of thermal vibration of each atom in the crystal is determined.

The X-ray diffraction (XRD) patterns of Cr:ZnS nanoparticles were recorded by Bruker system using radiation ($\lambda=0.154056$ nm) with 2θ ranging $5-70^\circ$.

1.4 Schematic diagram of X-Ray diffractometer

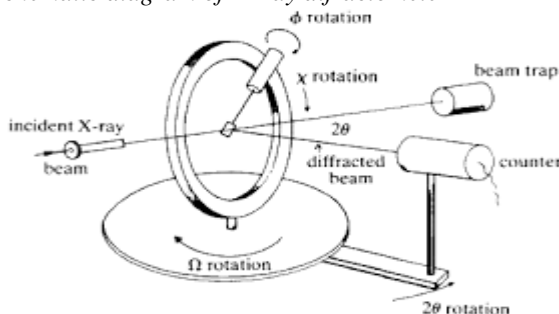


Fig.2 Schematic diagram of X-Ray diffractometer

1.5 Bragg's law: - A regular array of scatterers produces a regular array of spherical waves. Although these waves cancel one another out in most directions through destructive interference, they add constructively in a few specific directions, determined by Bragg's law:

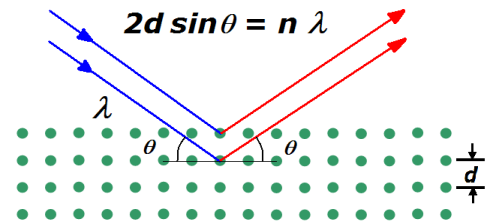


Fig.3 Bragg diffraction

Here d is the spacing between diffracting planes, θ is the incident angle, n is any integer, and λ is the wavelength of the beam. These specific directions appear as spots on the diffraction pattern called reflections. Thus, X-ray diffraction results from an electromagnetic wave (the X-ray) impinging on a regular array of scatterers (the repeating arrangement of atoms within the crystal) [4].

1.6 Calculation of peak plane by Bragg's law

$$n\lambda = 2d \sin \theta$$

Where,

λ = wavelength

d = Inter planer Spacing.

For, $2\theta = 43.2^\circ$

$$d = \frac{\lambda}{2 \sin \theta} = \frac{0.159 \text{ nm}}{2 \sin (43.2/2)} = 0.209 \text{ nm}$$

X-ray diffraction for chromium shows that it has a cubic body centered structure at wavelength of 0.154nm, one peak in the XRD pattern is at $2\theta = 43.2^\circ$.

The miller indices for this peak

$$d_{hkl} = \frac{a}{(h^2 + k^2 + l^2)^{1/2}}$$

For cubic centred, $a = 2r$.

r = Atomic radius = 0.128nm

At $2\theta = 43.2^\circ$ and $\lambda = 0.159$ nm it is calculated that plane lies [i.e. (111)].

1.7 Scherrer equation

The Scherrer equation, in X-ray diffraction and crystallography, is a formula that relates the size of sub-micrometre particles, or crystallites, in a solid to the broadening of a peak in a diffraction pattern. It is named after Paul Scherrer. It is used in the determination of size of particles of crystals in the form of powder.

The Scherrer equation can be written as:

$$t = \frac{k\lambda}{B \cos \theta}$$

Where:

t is the mean size of the ordered (crystalline) domains, which may be smaller or equal to the grain size.

K is a dimensionless shape factor, with a value close to unity. The shape factor has a typical value of about 0.9, but varies with the actual shape of the crystallite. $K = 0.9$

λ is the X-ray wavelength. $\lambda = 0.154$ nm

B is the line broadening at half the maximum intensity (FWHM), after subtracting the instrumental line broadening, in radians. This quantity is also sometimes denoted as $\Delta(2\theta)$. $B=0.5^\circ$
 θ is the Bragg angle (in degrees). $2\theta=27$

$$t = 0.9 \lambda / (B \cos \theta)$$

$$1. B = 0.5^\circ, \lambda = 0.154 \text{ nm}, 2\theta = 27^\circ$$

$$\theta = 13.5^\circ; \cos(13.5) = 0.972$$

$$360^\circ = 2 \times 3.142$$

$$0.5 = 0.5 \times 2 \times 3.142 / (360) = 0.00873$$

$$t = 16.3 \text{ nm}$$

2. If $t = 2 \text{ mm}$ then the value for B for same reflection is

$$B = 0.9 \lambda / (t \cos \theta)$$

$$= 1.386 / 2 \times 10^{-3} \times 0.972 = 7.12 \times 10^{-4} \text{ radians}$$

$$7.12 \times 10^{-4} \text{ radians} = 7.12 \times 10^{-4} \times 360 / (6.284) = 0.047^\circ$$

I.e. impossibly thin compared to resolution!

Note can write that $B = B_{\text{actual}} = \sqrt{(B_{\text{observed}}^2 - B_{\text{resolution}}^2)}$

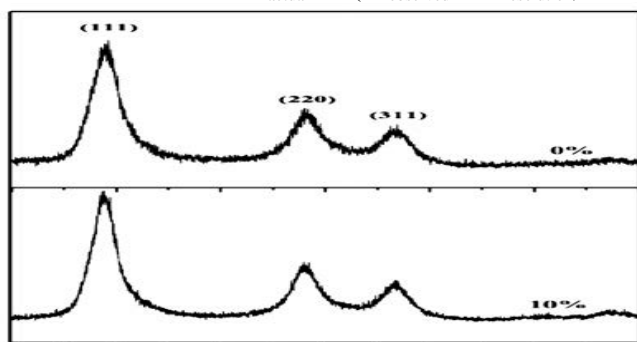


Fig. 4 The X-ray diffraction (XRD) patterns of Cr:ZnS nanoparticles

II. UV- ANALYSIS

2.1 Ultraviolet-visible spectroscopy:

UV-visible spectroscopy is type of absorption spectroscopy in which light of ultra-violet region (200-400 nm.) and visible region (400-800 nm.) is absorbed by the molecule. Absorption of the ultra-violet radiations results in the excitation of the electrons from the ground state to higher energy state. The energy of the ultra-violet radiation that is absorbed is equal to the energy difference between the ground state and higher energy states.

2.2 Principle of UV spectroscopy

UV spectroscopy obeys the Beer-Lambert law, which states that: when a beam of monochromatic light is passed through a sample of an absorbing substance, the rate of decrease of intensity of radiation with thickness of the absorbing sample is proportional to the incident radiation as well as the concentration of the sample.

The expression of Beer-Lambert law is- $A = \log(I_0/I) = ECL$
Where, A = absorbance I_0 = intensity of light incident upon sample cell I = intensity of light leaving sample cell C = molar concentration of solute L = length of sample cell (cm.) E = molar absorptivity. From the Beer-Lambert law it is clear that greater the number of molecules capable of absorbing light of a given wavelength, the greater the extent of light absorption. This is the basic principle of UV spectroscopy.

2.3 Basic terms used in UV-vis spectroscopy.

Chromophore- Chromophore is defined as any isolated covalently bonded group that shows a characteristic absorption in ultraviolet or visible region (200-800 nm). Chromophores can be divided into two groups-
a) *Chromophores-* which contain p electrons and which undergo π to π^* transitions. Ethylenes and acetylenes are the example of such chromophores.
b) *Chromophores-* which contain both p and nonbonding electrons. They undergo two types of transitions; π to π^* and nonbonding to π^* . Carbonyl, nitriles, azo compounds, nitro compounds etc. are the example of such chromophores.
Auxochromes- An auxochrome can be defined as any group which does not itself act as a chromophore but whose presence brings about a shift of the absorption band towards the longer wavelength of the spectrum. -OH,-OR,-NH₂,-NHR, -SH etc. are the examples of auxochromic groups.

2.4 Absorption and intensity shifts in the UV spectroscopy

There are four types of shifts observed in the UV spectroscopy-

a) *Bathochromic effect-* This type of shift is also known as *red shift*. Bathochromic shift is an effect by virtue of which the absorption maximum is shifted towards the longer wavelength due to the presence of an auxochrome or change in solvents. The nonbonding to π^* transition of carbonyl compounds observes bathochromic or red shift in the uv-vis spectrum.

b) *Hypsochromic shift-* This effect is also known as *blue shift*. Hypsochromic shift is an effect by virtue of which absorption maximum is shifted towards the shorter wavelength. Generally it is caused due to the removal of conjugation or by changing the polarity of the solvents.

c) *Hyperchromic effect-* Hyperchromic shift is an effect by virtue of which absorption maximum increases. The introduction of an auxochrome in the compound generally results in the hyperchromic effect.

d) *Hypochromic effect-* Hypochromic effect is defined as the effect by virtue of intensity of absorption maximum decreases. Hyperchromic effect occurs due to the distortion of the geometry of the molecule with an introduction of new group.

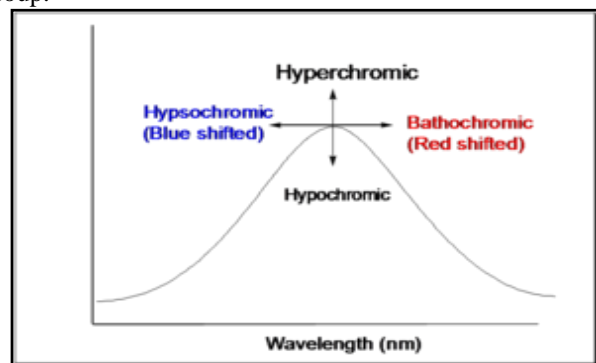


Fig.5 Absorption and intensity shifts in the UV spectroscopy

2.4 Applications of UV spectroscopy

i. **Detection of functional groups-** UV spectroscopy is used to detect the presence or absence of chromophore in the compound. This is technique is not useful for the detection of

chromophore in complex compounds. The absence of a band at a particular band can be seen as an evidence for the absence of a particular group. If the spectrum of a compound comes out to be transparent above 200 nm than it confirms the absence of –

- a) Conjugation
- b) A carbonyl group
- c) Benzene or aromatic compound
- d) Bromo iodo atoms.

ii. Detection of extent of conjugation- The extent of conjugation in the polyenes can be detected with the help of UV spectroscopy. With the increase in double bonds the absorption shifts towards the longer wavelength. If the double bond is increased by 8 in the polyenes then that polyene appears visible to the human eye as the absorption comes in the visible region of the electromagnetic spectrum.

iii. Identification of an unknown compound- An unknown compound can be identified with the help of UV spectroscopy. The spectrum of unknown compound is compared with the spectrum of a reference compound and if both the spectrums coincide then it confirms the identification of the unknown substance.

iv. Determination of configurations of geometrical isomers- It is observed that cis-alkenes absorb at different wavelength than the trans-alkenes. The two isomers can be distinguished with each other when one of the isomers has non-coplanar structure due to steric hindrances. The cis-isomer suffers distortion and absorbs at lower wavelength as compared to trans-isomer present in the sample.

v. Determination of the purity of a substance- Purity of a substance can also be determined with the help of UV spectroscopy. The absorption of the sample solution is compared with the absorption of the reference solution. The intensity of the absorption can be used for the relative calculation of the purity of the sample substance.

Solvents commonly used in UV/visible spectroscopy	
Solvent	Wavelength cutoff
Water	190 nm
Acetonitrile	190 nm
Cyclohexane	195 nm
Methanol	205 nm
95% ethanol	205 nm

Table .2 Solvent commonly used in UV-visible spectroscopy.

The optical absorption spectra of nanoparticles were measured using a USB-2000 UV-visible spectrophotometer. Therefore, obtained nanopowders have been suspended in glycerol using magnetic stirrer and their optical absorption spectra has been recorded at room temperature over the range 200 to 800 nm for determining the energy band gap values, purity of the sample and concentration of the sample.

2.5 The electronic transition in UV region is given as follows.

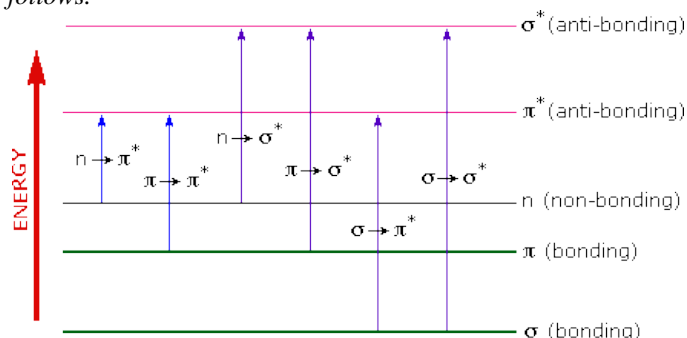


Fig.6 The electronic transition in UV region

The absorption spectra of the different samples are shown in Fig 7. The absorption edge is observed in the range of 325–280 nm, which is blue shifted compared to bulk ZnS. As the Cr concentration increases, the absorption edge shifts to lower wavelength side and intensity also increases with increasing Cr concentration compared to undoped ZnS. This blue shift of the absorption edges for different sized nanoparticles is related to the size decrease of particles and is attributed to the quantum confinement limit reaching of nanoparticles. The quantum confinement effect is expected for semiconducting nanoparticles, and the absorption edge will be shifted to a higher energy when the particle size decreases. It is necessary to mention that the optical band gap values of the Cr:ZnS nanoparticles were determined by Tauc's relation (Tauc, Where $h\nu$, α_0 and E_g are photon energy, a constant and optical band gap of the nanoparticles, respectively^[5]).

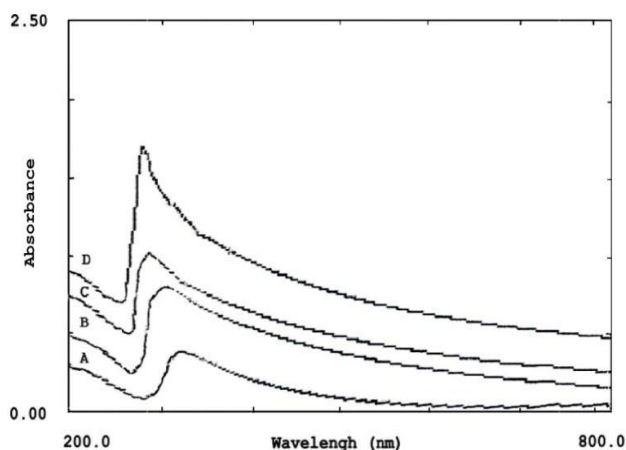


Fig 7. Absorption of UV radiation by Cr: ZnS nanoparticles. Absorption coefficient (α) of the powders at different wavelengths can be calculated from the absorption spectra. The values of optical band gap ' E_g ' increases with the increase in molar concentration doping agent and therefore decrease particles size that as mentioned earlier is due to quantum confinement effect. The optical band gap values of nanoparticles have changed from 3.82 to 4.42 eV by decreasing the particle sizes. The increase in band gap with increase in Cr concentration is attributed to size quantization effect due to the small size of the particles Chemical reaction rate directly affects the time evolution of the number of nuclei, which determines both nucleation and growth

process. First, the influence on nucleation is obvious: nucleation is faster when the chemical reaction is faster. Second, growth will be strongly influenced by the nuclei number already formed at a given time. A great number of nucleation favours a fast autocatalytic growth, giving rise to a large number of small particles. Rate of reaction controls this kind of growth, being the autocatalytic growth faster as chemical reaction is faster. But in nanoparticle formation, there is another contribution to the growth molecules on the surface of small particle will tend to diffuse through solution and add to the surface of larger particle (growth by ripening). A slow chemical reaction favours continuous nuclei, keeping always a certain number of nuclei in the system. As a result, growth by ripening can take place during the whole process. This fact explains the bigger particle size obtained from a slow reaction. One can conclude that a slow chemical reaction rate is associated with a more important ripening contribution to the growth. A high number of nuclei are still forming at this stage when the reaction is slow at the same time; some particles have already grown to the final value of size. This means that in this case (slow reaction rate), nucleation and growth takes place simultaneously. This overlapping of nucleation and growth processes, which is more pronounced as the chemical reaction is slower, leads to larger nanoparticle sizes. Mean crystallite size and study, the molar concentration of reactants solution varies from 0 M to 1.5 M, the reaction rate is highest for 1.5 M solution and hence the particle size obtained is smallest for 1.5 M solution as compared to other materials in the series, which is in consistent with the above made argument.

2.6 Calculation of energy band gap using UV-VIS Spectrometer

The term “band gap” refers to the energy difference between the top of the valence band to the bottom of the conduction band (See Figure 8); electrons are able to jump from one band to another. In order for an electron to jump from a valence band to a conduction band, it requires a specific minimum amount of energy for the transition, the band gap energy. Measuring the band gap is important in the semiconductor and nanomaterial industries. The band gap energy of insulators is large (> 4eV), but lower for semiconductors (< 3eV).

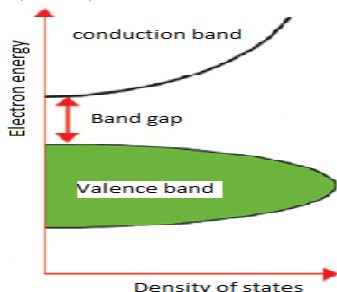


Fig 8. Explanation of Band gap

2.7 Determination of energy band gap.

i. By normal method

Band gap energy, $E = \frac{hc}{\lambda}$
 $h=6.62 \times 10^{-34} \text{Js}$, $c=3 \times 10^8 \text{m/s}$

Therefore, $E = \frac{1.24 \times 10^{-6}}{\lambda} \text{ eV}$, λ in meter
 $E = \frac{1242.37}{\lambda} \text{ eV}$, λ in meter.

ii. By Tauc method

$$\alpha = \frac{A(h\nu - E_g)^n}{h\nu}$$

By rearranging the above equation,

$$(\alpha h\nu)^{\frac{1}{n}} = A^{\frac{1}{n}} h\nu - A^{\frac{1}{n}} E_g$$

Where $\alpha = \ln\left(\frac{1/T}{x}\right)$

α = absorption coefficient

T= Transmittance

x=Thickness of the sample

E_g = Band gap of the material

$n = 2, 1/2, 2/3$ and $1/3$ for direct allowed, indirect allowed, direct forbidden, and indirect forbidden transition respectively.

Plotting graph of $(\alpha h\nu)^{1/n}$ Vs $h\nu$, we will get slope as $A^{1/n}$ and y intercept as $A^{1/n}$. Dividing y intercept by $A^{1/n}$ we can estimate the band gap.

iii. Thickness calculation

Absorbance $A = -\text{Log}(I/I_0)$

$$I = I_0 e^{-t/\delta}$$

Where,

I_0 = intensity of glass plate

I = intensity of the coated glass sample

t = thickness of the sample

δ = skin depth of the material

$$\delta = \sqrt{\frac{\rho\lambda}{\pi c\mu}}$$

where,

ρ = Resistivity

λ = Wavelength

c = velocity of light

μ = absolute magnetic permeability [6].

3. EDS Study

Energy Dispersive X-ray Spectroscopy (EDS, EDX or XEDS) is a qualitative and quantitative X-ray microanalytical technique that can provide information on the chemical composition of a sample for elements with atomic number (Z) >3. An electron beam is focused on the sample in either a scanning electron microscope (SEM) or a transmission electron microscope (TEM). The electrons from the primary beam penetrate the sample and interact with the atoms from which it is made. Two types of X-rays result from these interactions: Bremsstrahlung X-rays, which means ‘braking radiation’ and are also referred to as Continuum or background X-rays, and Characteristic X-rays. The X-rays are detected by an Energy Dispersive detector which displays the signal as a spectrum, or histogram, of intensity (number of X-rays or X-ray count rate) versus X-ray energy. The energies of the Characteristic X-rays allow the elements making up the sample to be identified, while the intensities of the Characteristic X-ray peaks allow the concentrations of the elements to be quantified. The X-rays are detected by an Energy Dispersive

detector which displays the signal as a spectrum, or histogram, of intensity (number of X-rays or X-ray count rate) versus X-ray energy. The energies of the Characteristic X-rays allow the elements making up the sample to be identified, while the intensities of the Characteristic X-ray peaks allow the concentrations of the elements to be quantified. Energy dispersive spectra (EDS) were recorded at room temperature in the range of 0-20 keV with the count rate of 7277 cps for the chemical composition analysis. It is confirmed that there are no extra traces. It is intervened that the as prepared samples are highly pure. From our EDS study it is acknowledged that exact percentage of chemical compositions is highly matchable with standard results. This study reveals accurate information about the sample.

Fourier transform infrared spectroscopy (FTIR).

Fourier Transform Infrared (FTIR) spectroscopy is a powerful tool for identifying types of chemical bonds in a molecule by producing an infrared absorption spectrum that is like a molecular "fingerprint". It can be utilized to quantitate some components of an unknown mixture. It can be applied to the analysis of solids, liquids, and gasses. The wavelength of light absorbed is characteristic of the chemical bond as can be seen from the spectrum. By interpreting the infrared absorption spectrum, the chemical bonds in a molecule can be determined. FTIR spectroscopy does not require a vacuum, since neither oxygen nor nitrogen absorbs infrared rays. Molecular bonds vibrate at various frequencies depending on the elements and the type of bonds. For any given bond, there are several specific frequencies at which it can vibrate. According to quantum mechanics, these frequencies correspond to the ground state (lowest frequency) and several excited states (higher frequencies). One way to cause the frequency of a molecular vibration to increase is to excite the bond by having it absorb light energy^[11]. For any given transition between two states the light energy (determined by the wavelength) must exactly equal the difference in the energy between the two states [usually ground state (E_0) and the first excited state (E_1). The energy corresponding to these transitions between molecular vibrational states is generally 1-10 kilocalorie/mole which corresponds to the infrared portion of the electromagnetic spectrum^[7].

4. FTIR can provide following information about the sample:

It can identify unknown materials.

It can determine the quality or consistency of a sample.

It can determine the amount of components in a mixture.

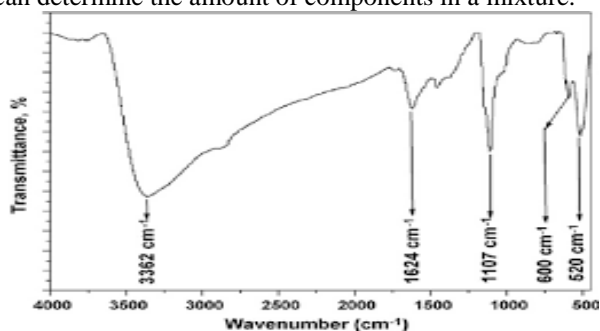


Fig. 9 The FTIR spectrum of Cr:ZnS

The FTIR studies of the samples were done using BRUKER optics, Germany spectrometer in the wave number range 400-4000 cm^{-1} . The FTIR spectrum of Cr:ZnS is shown in Fig .9 In this spectrum the bands at 3814 cm^{-1} , 3227 cm^{-1} correspond to the O-H vibrations of water molecules, the peak at 2870 cm^{-1} correspond to the C-H bond, the band at 2369 cm^{-1} show the presence of CO_2 in the sample. The band at 1578 cm^{-1} corresponds to the hydroxyl group present in the sample. The acetate bands of C-O are observed at 1215 cm^{-1} . The band at 630 cm^{-1} corresponds to the vibration of Zn-S. The absorption bands near 3458 cm^{-1} represent O-H mode, those at 2956 cm^{-1} are C-H mode, and the peaks near 1400-1700 cm^{-1} are the C=O stretching mode. The absorption peaks at 663 cm^{-1} corresponds to the vibrations of Zn-S. The peaks formed at 700-900 cm^{-1} are attributed to the bond between Chromium and Sulphur. Also we can observe additional peaks in the wave number region 600-1300 cm^{-1} which is the region of Zn-S and Cr-S bonding which again represent the presence of additional phases at higher concentration of doping^[8].

Applications of Cr: ZnS.

By the study and observations it is found that chromium (Cr) doped Zinc Sulphide nanoparticle have wide verity of application in optoelectronics by controlling their band gaps, polarization of light by determining the absorption and transmittance from UV-visible spectroscopy and FTIR, being the particle completely stable and non toxic it is used for targeted drug delivery system, by the spectral analysis it found that these particles are can be used to prepare colloidal solution and micro emulsions for protection and shield of other corrosive materials like iron, zinc ,copper etc^[9].

III. RESULTS AND DISCUSSION

Structural Characterization The XRD patterns of prepared ZnS:Cr nanoparticles with different amounts of doping agent $\text{Cr}(\text{NO}_3)_2$. All of the crystalline Bragg peaks in the XRD pattern ((111), (220) and (311) planes) are in a good agreement with the diffraction data of cubical structure with cell parameters $a=3.600 \text{ \AA}$ and $c=6.130 \text{ \AA}$. Furthermore, The peak broadening in the XRD patterns clearly indicates the formation of ZnS: Cr nanocrystals with very small size. The peak broadening at lower angle is more meaningful for the calculation of particle size, the mean crystallite size of nanoparticles was also estimated using the Scherrer formula, reflection from the XRD pattern as follows: Where λ , B, and θ are the X-ray wavelength of the radiation used ($\lambda = 0.154056 \text{ nm}$), the full width at half maximum (FWHM) of the diffraction peak and the Bragg diffraction angle, respectively. The values of mean crystallite size obtained from XRD for different molar doping agent

IV. CONCLUSIONS

It is possible to produce different size ZnS:Cr nanoparticles using a simple chemical co precipitation method by using different molar concentration of doping agent. XRD and energy band gap data have been obtained to confirm nano size of the particle. It is also observed that the particle size depends on molar concentration of doping agent. A decrease in formation rate of nanoparticles gives rise to a larger final

particle size for all the studied synthesis conditions. Chemical reaction rate affects both nucleation and growth process. Nucleation and growth take place simultaneously when the chemical reaction is slow. Besides, a slow chemical reaction rate is associated with a more important ripening contribution to the growth. As the particle size depends upon the molar concentration of doping agent, a decrease in the size of particle is observed with the increase of molar concentration of doping agent. The mean crystallite size range of particles was between 1.5 and 2.45 nm, depending on molar concentration of doping agent. The energy band gap values of ZnS:Cr nanoparticles have changed from 3.1 to 4.5 eV by increasing the molar concentration of doping agent. These values exhibit a blue shift in E_g which is related to the size decrease of the particles and to the quantum confinement limit reaching of nanoparticles^[10]. Considering these results, the chemical co-precipitation method using poly vinyl alcohol as a capping agent is efficient for the preparation of ZnS: Cr nanoparticles suitable for modern optoelectronic technology and other electronics industries.

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