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INVESTIGATIONS ON THE PROPERTIES OF COPPER SULPHIDE NANOPARTICLES

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Abstract - *Nanotechnology has gained mammoth attention in the recent decades, due to its enhanced light absorption which can be used for the rationale deployment of light energy and ought to have reflective collision on countless interrelated areas of discipline in technology. Copper sulphide nanoparticles for advanced environmental applications were synthesized by a facile solvothermal route using copper and sulphide as precursor. The effect of the precursors morphological and optical properties was studied. The as-synthesized nanoparticles were analysed using X-ray Diffraction, Transmission electron microscope, UV-visible and Photoluminescence. The phase formation of the nanosized CuS particles were examined using X-ray diffraction and the crystallite size was found to be around 19nm. The morphology of the agglomerated CuS nanoparticles was depicted from TEM micrograph. The optical properties of the as-synthesized nanoparticle were revealed by Uv-visible spectra and PL spectra. The band gap was calculated using Kubelka-Munk plot and the band gap was found to be 2.02 eV.*

***KeyWords*: Copper Sulphide(CuS), Solvothermal Technique, Nanoparticle.**

1. INTRODUCTION

Copper Sulphide is known to subsist for a numerous choice of stable and unstable phases and it is a p-type Semi conductor [1]. Copper -based nanoparticles are of enormous interest due to their low cost as well as easily available and its belongs to a family of chemical compounds and minerals with the formula CuS. They occurs naturally in environment as a mineral called covellite[2]. It conducts electricity reasonably in both minerals and synthetic materials encompass these compounds [3]. Some copper sulphide are efficiently important ores. Prominent copper sulphide minerals include Cu_2S (chalcocite) and CuS (covellite). In the progress of mineral industry, the minerals bornite or chalcopyrite, which consist of mixed copper-iron sulphides, are often referred to as "copper sulphides" with a crystal structure varying from orthogonal to hexagonal [4,5]. In the present study solvothermal method of synthesis had been adopted to synthesize copper monosulphide nanoparticles since this method provides a superior nucleation control while eliminating the contamination rate.

2. EXPERIMENTAL PROCEDURE

Copper and Sulphide were the Precursors used where in Copper was obtained from Copper Chloride dihydrate and sulphide from thiourea, Precussor were taken in the Ratio 1:3 that is 1.27 gram of Copper Chloride dehydrate was dissolved in 75 ml ethanol using magnetic stirrer. The mixing process of one liquid with another was done with great accuracy were the second liquid was mixed drop by drop with the continuous stirring using a Magnetic Stirrer. The obtained solution were poured into a autoclave and placed in the muffle furnance for 6 hr at a temperature 200 ^{0}C for the formation of CuS nanoparticles took place under a controlled and contamination-free environment, After six hours the autoclave was allowed to cool down naturally to ambient room temperature. The dark green precipitate thus obtained was washed by centrifugation with the help of double distilled water and absolute ethanol to remove the chloride impurities present in the sample and the product obtained was consequently allowed to dry overnight in a hot air oven at 80 ºC. The green solids obtained were ground well in a granite mortar to attain fine grained nano CuS particles.

3. RESULTS AND DISCUSSIONS

3.1 X-ray Diffraction

The crystalline of the nanosized CuS particles were examined using X-ray diffraction (XRD) patterns, recorded by Scifert analysis with Cuk$_\alpha$ radiation (λ=1.5406Å) in the 2θ range 20° to 70°.Which shows the XRD patterns of the synthesized samples CuS nanoparticles synthesized with the

solvents ethanol respectively[6]. From Figure .1 the spectra it is observed that the major diffraction peaks at (101), (102), (103), (006), (105), (110), (108) and (116) planes match well with those expected for hexagonal structure of covellite CuS (JCPDS06-0464). Therefore we can infer that the solvent ethanol favours the production of pure CuS nanoparticles.

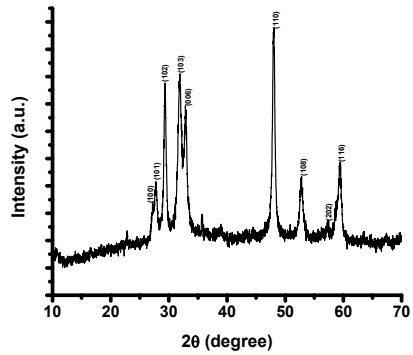

Figure -1: XRD diffraction pattern of CuS

The most prominent peak corresponding to (110) plane is used to calculate approximate size of the particle by using Scherrer equation,

$$D = \frac{k\lambda}{\beta cos\theta} \quad (1)$$

Where,

- **D** is the average particle size
- **λ** is the wavelength of copper K_α line (1.546 Å)
- **θ** is the diffraction angle
- **β** is the full width at half maximum value
- ***k*** is a constant

Using the above formula, the approximate crystallite size was estimated to be 19.34 nm for ethanol. Thus the solvent ethanol helps in yielding a small particle size.

3.2 Transmission electron microscopy

The morphology and particle size of the nanoparticle CuS prepared by solvothermal method was investigated by Transmission Electron microscope (TEM). The TEM micrograph Figure .2 represents a homogenous morphology of the nanoparticles. The lattice fringes exposed in the inset figure evidence the crystalline nature of the prepared CuS nanoparticles.

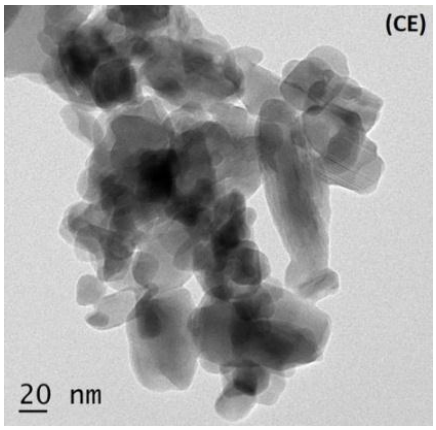

Figure -2: TEM for CuS nanoparticle

3.3 Optical analysis (UV –vis and PL)

All particles demonstrate a broad absorption over the entire visible region. This broad absorption in the visible range is a desirable feature for application (solar spectrum) . The band gap of the synthesized particles, which is an essential characteristic of a semiconductor, and was calculated using the Kubelka-Munk

$$\varepsilon h\upsilon = A(h\upsilon - E_g)^n \quad (2)$$

where ε is the molar extinction coefficient, A is a constant, E_g is optical band gap of the sample and $h\upsilon$ is photon energy.

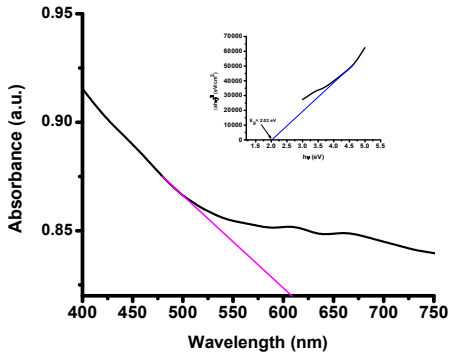

Figure -3: UV–Vis absorption spectrum of CuS

In the above equation, n depends on the type of transition which is ½ and 2 for direct and indirect allowed transition respectively. A graph is plotted between $(\varepsilon h\upsilon)^2$ and $h\upsilon$ and the intersection of the extrapolated linear part of the curve at x-axis gives the optical band gap of the synthesized CuS nanoparticles. The Kubelka-Munk of the samples are shown

in Figure .3. The band gap of the samples 2.02 eV respectively.

The Photoluminescence spectra of the CuS sample synthesized by solvothermal method is provided that an excitation at 370 nm, In Figure .4 the sample demonstrates an intense emission peak at around 416 nm and weak peaks in the range of 475-550 nm. The results are reliable with the literature reports. It can be described that the exhibition of weak peaks in the 475-550 nm range might be due to the surface defects and an interface coupling effect between the grain boundaries.

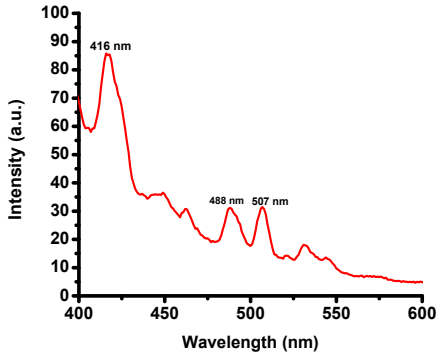

Fig - 4: Photoluminescence of CuS

4. CONCLUSION

The current work was focused on the preparation of copper sulphide by solvothermal method. The prepared nanoparticles were characterized by X-ray Diffraction (XRD) study, Transmission Electron Microscope (TEM), Photo luminescence (PL), Ultra Violet Visible (UV). Powder X-ray diffraction studies indicate that CuS nanoparticles exhibit hexagonal structure with the particle size of 19.34 nm the samples synthesized for ethanol. From the Uv-visible absorption studies the band gap of CuS nanoparticles were found to be 2.02 eV The Photoluminescence (PL) measurement of the nanoparticles synthesized for ethanol respectively have been described to a high level transition in CuS Semiconductor Crystallites. It has been reported that this kind of band edge luminescence.

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