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STUCTURAL AND OPTICAL CHARACTERIZATION OF CuO NANORODS BY WET CHEMICAL METHOD

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Abstract. CuO nanorods was prepared using wet chemical method. Particle size and phase of the as prepared nonorods was determined using single crystal X- ray diffraction. Surface morphology was seen using scanning electron microscope (SEM). Functional group of CuO nanorods was confirmed by FTIR. Optical properties of CuO nanorods were calculated and energy band gap of as prepared nanorod is 2 eV.

Keywords: Nanorods, wet chemical method, CuO, SEM and optical.

1. INTRODUCTION

In the past decades, one-dimensional, nano structured, inorganic semiconductor materials are currently the focus of considerable interest, because they often possess unique chemical, mechanical and physical properties, and may prove to be the key components in many applications including nano electronics, nano photonics, nano computing and nanoscale bio and chemical sensing. CuO has been established as a technologically important material with its numerous applications in the fields, like gas sensors [1,7,9,16], photo catalysis [8, 10], solar photovoltaics [6], lithium ion electrode [15, 18], nano fuel [12], antimicrobial [10], and bio sensors [17]. As the chemical and physical properties of CuO are dependent on its size and shape considerable efforts have been made to synthesize various CuO nano - and microstructures with controllable morphology. CuO nanostructures such as nanorods [15], nanowires [1], nanoneedles [2, 15], nanoribbons [16], spheroidal [14, 18], hollow spheres [11], have been extensively studied. In this work CuO nanorods was prepared and its properties were reported.

2. EXPERIMENTAL PROCEDURE

Copper nitrate hexahydrate, PEG 400, NaOH pellets were purchased from Sigma Aldrich and all of the chemical reagents were analytical grade and used without further purification. Cu (NO_3) of (0.1) molarity solution was prepared and 5 ml of PEG 400 was added to that solution. This solution was stirred using magnetic stirrer for one hour. NaOH (0.1 molarity) solution was added by drop wise under constant stirring until the pH of the solution reached 12 and brown precipitate was obtained. The as obtained precipitate was filtered and then washed several times with distilled water and ethanol. It was dried on 60°C and calcinied at 150°C. The powder was crushed into fine powder by pestle and mortar.

3. CHARACTERIZATIONS

The XRD pattern was recorded by XPERT-PRO diffractometer using Cu- Kα radiation ($\lambda = 1.54060$) in order to determine the phase present in the as prepared material. Infra red spectrum was recorded using KBR pellet technique. SEM image was recorded using the Scanning Electron Microscope (Carl Zeiss EVO 18). UV Vis spectrum was recorded and optical properties of prepared material was studied.

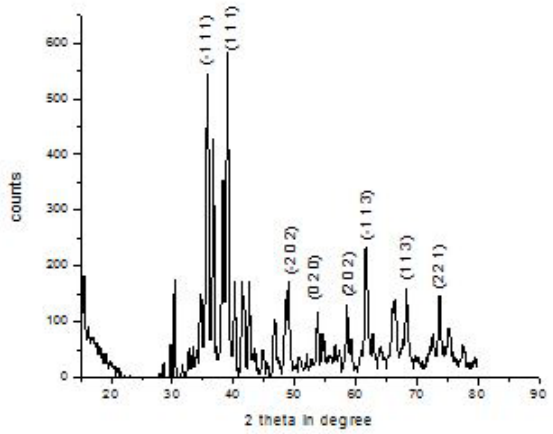

FIGURE 1. X-ray diffraction of CuO nanorods

3.1. **Results and discussion.** XRD pattern of the CuO nano rods is shown in Fig.1. The formation of crystalline CuO nano structures was confirmed by the XRD pattern. The grain sizes for different FWHM values were calculated using Debye scherrers equation $D = K\lambda/\beta cos\theta$, where K is constant (shape factor, about 0.9), the X-ray wavelength is 1.54060 Å, for the full width half maximum (FWHM) of the diffraction angle. Particle size was calculated for highest eight peaks. It various from 6 nm to 12 nm and the average particle size was 9 nm. Qualitative and quantitative phase analysis was made using match software using the data base COD- In org REV 140301. It was matched with the entry number 96-101-1149. All the diffraction peaks

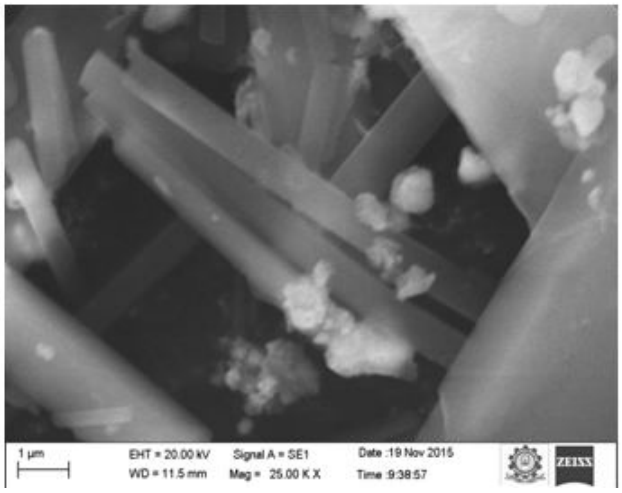

FIGURE 2. Scanning Electron Microscope image of CuO nanorods

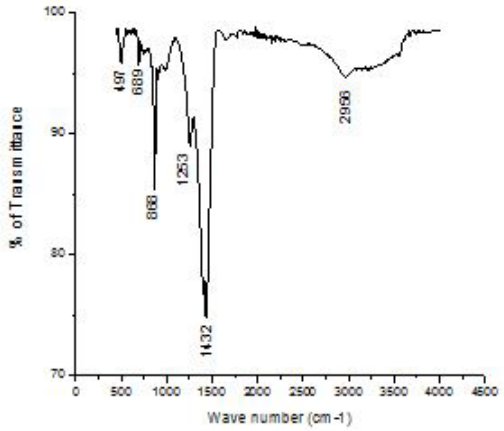

FIGURE 3. FTIR of CuO nanorods

can be indexed to the monoclinic phase of CuO with lattice parameters are a= 4.6530 Å, b= 3.4100 Å, c= 5.1080 Åand β=99.46.

In order to observe the structural morphology of the synthesized CuO nanostructures, the samples were probed by a scanning electron microscope (SEM). Fig.2 shows the SEM images of CuO nanostructures. It reveals that the detailed morphology of CuO product is well-defined Nanorods. Fig 3 shows FTIR pattern of the CuO nano rods. In this pattern, peak at 1290 -1590 cm^1 were assigned to the bending vibrations of the hydroxyl group combined with copper atoms [5] which indicates the presence of water molecule. The peaks appearing at 497, 689 and 868 cm^1, are related to the CuO stretching vibration[4, 7] and to conforms the formation of CuO. But the peaks which corresponds to metal oxide vibrations are not strong which indicates the

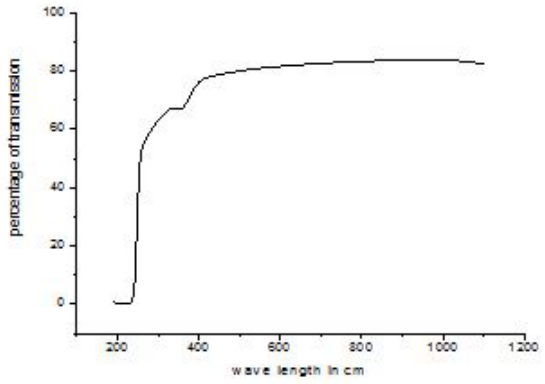

FIGURE 4. Optical transmittance of CuO nanorods

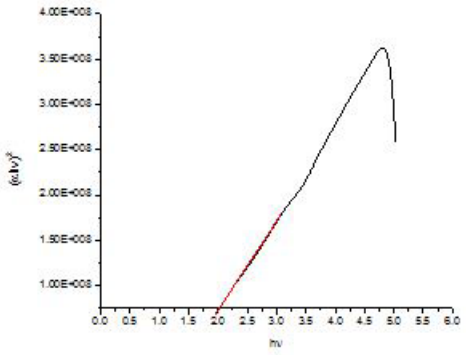

FIGURE 5. Energy band gap of CuO nanorods

formation is not complete. It may be due to the low temperature calcination. UVvis absorption measurements are one of the most efficient technique for investigating the optical properties of semiconductor nano materials. Fig.4 shows the UV Vis spectrum of the CuO nanorods. In this graph cut off region is at 227 cm. The energy band of the material is related to the absorption coefficient () by the Taucs relation, h = A(h - E_g)n, where A is a constant, h is the photon energy ($\nu = c/\lambda$), Eg is the band gap and n = 1/2 for an allowed direct transition. Plotting a graph between $(\alpha h\nu)^2$ and hν and extrapolation of the straight line to

$$(\alpha h\nu)^2 = 0$$

gives the value of the band gap. Calculated optical bandgap of the CuO nanorods was 2 eV which is greater than the bulk value (1.85 eV). The increase in the band gap of the CuO nanocrystals is attributed to the well-known quantum size effect [2]. The energy band gap of the as prepared nanorod of CuO is shown in Fig.5

4. Conclusion

CuO nano rods were prepared using simple wet chemical method. XRD pattern confirms the crystalline nature of the material and the particle size is in 6 nm to 12 nm. SEM image shows the formation of rod structure. FTIR spectrum confirms the formation of CuO by showing the peak for metal oxygen vibration (Cu O) bond. UV spectral studies give the optical band gap value of the material which is 2 eV.

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