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Studying structural and optical properties of ZnO-CdO nanocomposites

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ABSTRACT

Zinc oxide, cadimium oxide and their composites were synthesized in this research using sol-gel method and characterized by X-ray diffraction, to investigate their optical properties using UV-visible, photoluminenscence (PL) spectroscopy, which showed red shift behavior in the ZnO manner enhanced by addition of CdO which noticed through calculations of energy gap.

***Keywords*:** ZnO, CdO, ZnO-CdO, nanocomposite, sol gel, nanocomposites

1. INTRODUCTION

Zinc oxide (ZnO) has considerable customary attention due to its unique morphology and Dimension -dependent optoelectronic properties [1]. It has special properties, such as high Chemical activity, and novel optical, mechanical, electromagnetic, thermodynamic and electrodynamic properties, and displays a wide spectrum of applications, including gaseous sensors [2], fluorescent materials [3], photocatalysts [4], and additives in many industrial products [5]. Furthermore, ZnO is an environmentally friendly material, which is desirable especially for bio-applications, such as bio-imaging and cancer detection [6]. ZnO thin film is one of the II-VI compound semiconductors and is composed of hexagonal wurtzite, crystal structure. Cadmium oxide (CdO) is a well known II-VI semiconductor with a direct band gap of 2.2 eV (520 nm) and has developed various applications such as its use in solar cells, transparent electrodes, photodiodes, and sensors. There are numerous reports on the synthesis of the nanostructured ZnO-CdO through the usage of different methods including the Sol-Gel [7], vapor phase transport [8], reactive sputter [9] and spray-pyrolysis-techniques [10].

2. MATERIALS AND METHOD

In this method zinc nitrate hexa hydrate, cadmium nitrate tetra hydrate, were used in different ratios and (8gm) polyvinyl alcohol dissolved in 88 gm of ethanol and Double Deionized water (50:50) with continuous stirring until reaching homogeneous solution and left for about 24 hours then deposited using spin coating with speed about (2000) r.p.m, then followed by heat treatment at 600 ºC for 6 hours.

3. STRUCTURAL STUDIES

X-ray diffraction spectra

XRD pattern is used to determine the nature of the film and the structural characteristics of the materials used ZnO, CdO, and their composites using lab XRD Shimadzu of Measurement Condition X-ray tube of target Cu, voltage 40.0 (kV), current 30.0 (mA) the average grain size of the sample have been estimated using Scherrer's equation:

$$\mathbf{D = 0.94\lambda/\beta \, Cos \, \Theta} \qquad \text{..............(1)}$$

where λ is the wavelength (λ = 1.542 Å) (CuKα), β is the full width at half maximum (FWHM) of the line, and θ is the diffraction angle.

4. THICKNESS MEASUREMENT

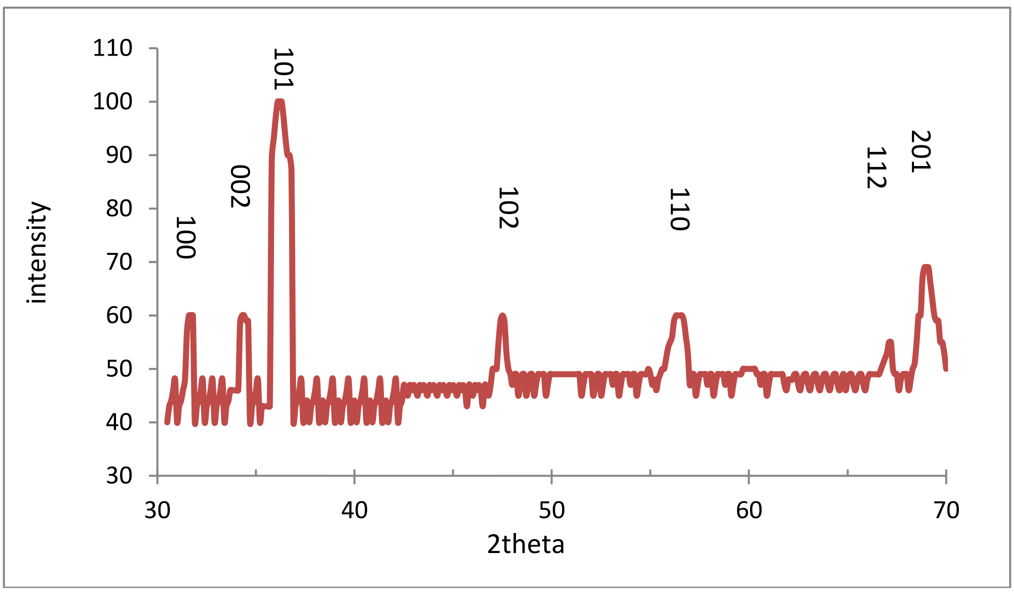
Interferometer method is used to measure film thickness using light beam reflection from film surface and substrate bottom. He-Ne Laser (632.8) nm is used to find thickness from formula:

$$d = \frac{\Delta x \cdot \lambda}{x \cdot 2} \qquad \text{......................(2)}$$

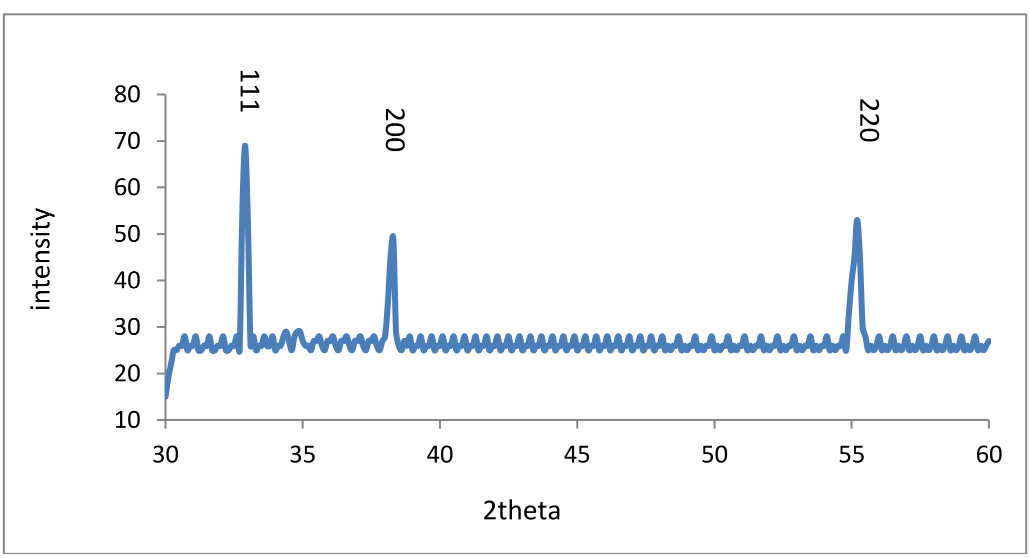
where x is fringe width, Δx is the distance between two fringes using He-Ne Laser (632.8) nm.

Optical properties

UV-VIS transmittance & Photoluminescence were studied at room temperature, have been used to determine the optical properties of ZnO, CdO, and their composites using shimadzu spectrometer (2000) of range 190-1100 nm. The XRD for pure ZnO, pure CdO, and their different compositions are shown in Fig (1) where hkl parameters indicated on each peak as in Table (1). The optical properties for the same tested samples shown in Fig. (2), Eg values were estimated for each case as in Table (1). While Photoluminescence were tested for samples using excitation wavelength of 320 nm as shown in Fig. (3).



(a)



(b)

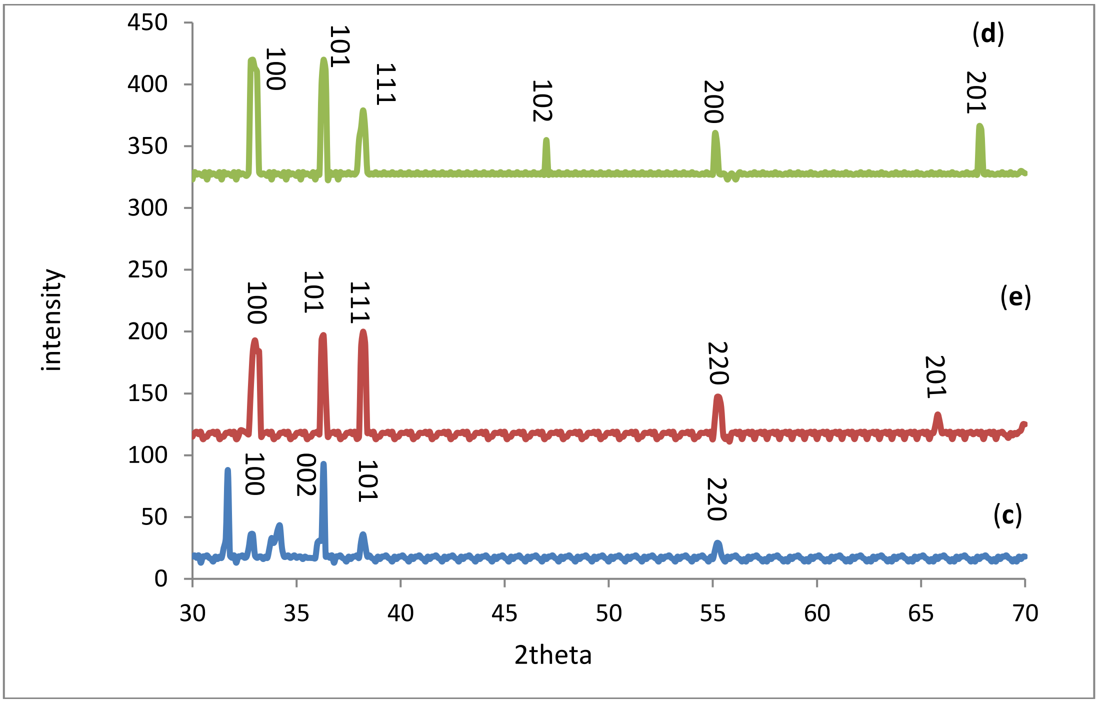
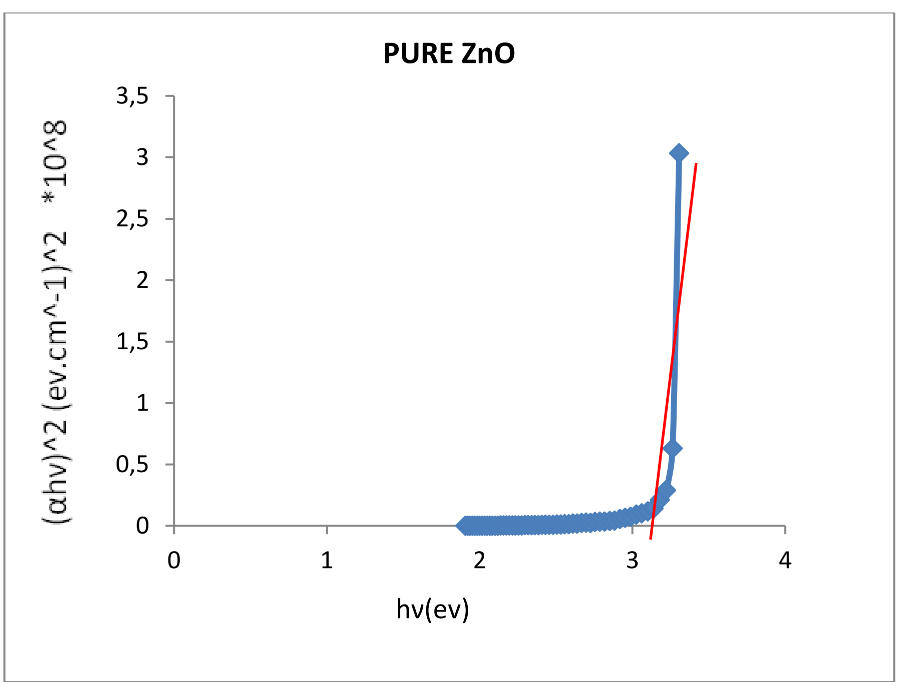
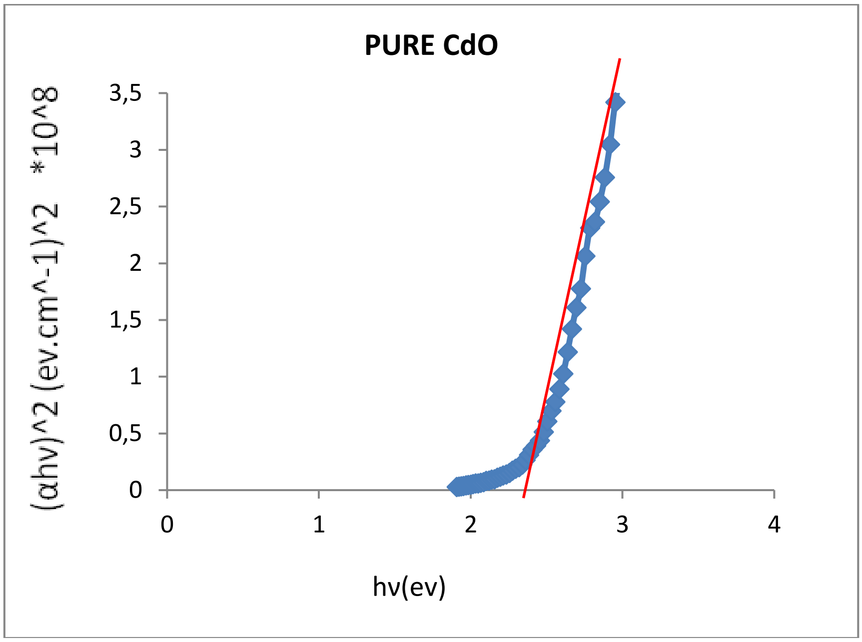


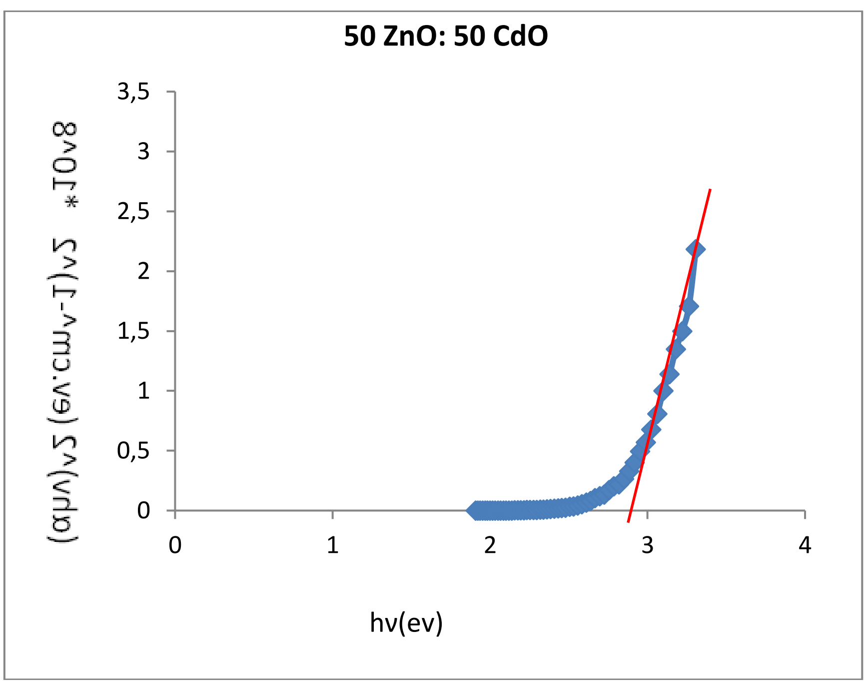
Fig. 1. XRD structures for: a - pure ZnO, b - pure CdO, c - 75 ZnO: 25 CdO, d -50 ZnO: 50 CdO, e - 75 CdO: 25 ZnO.



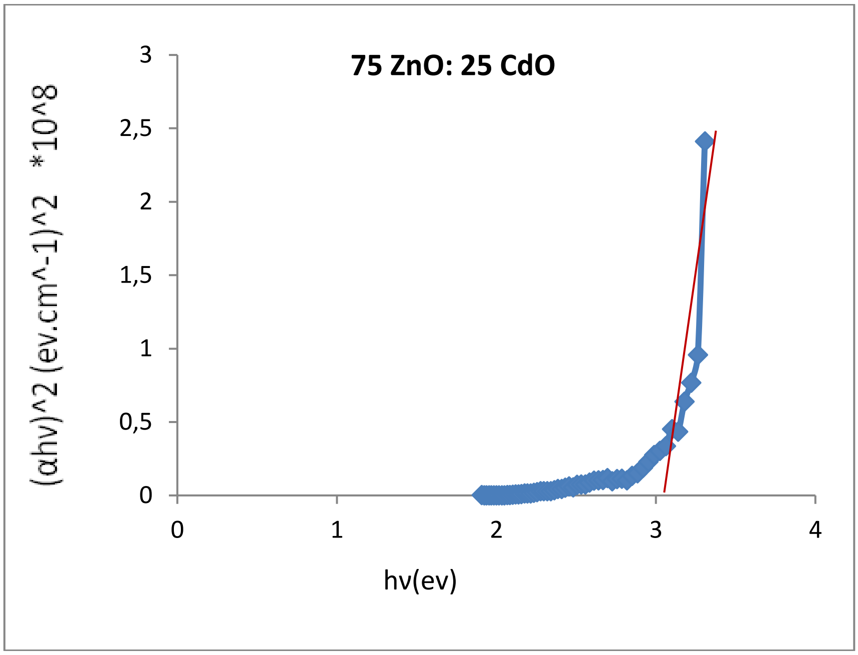
(a)


PURE CdO
(αhν)^2 (ev.cm^-1)^2 *10^8
3,5
3
2,5
2
1,5
1
0,5
0
0
1
2
3
4
hν(ev)

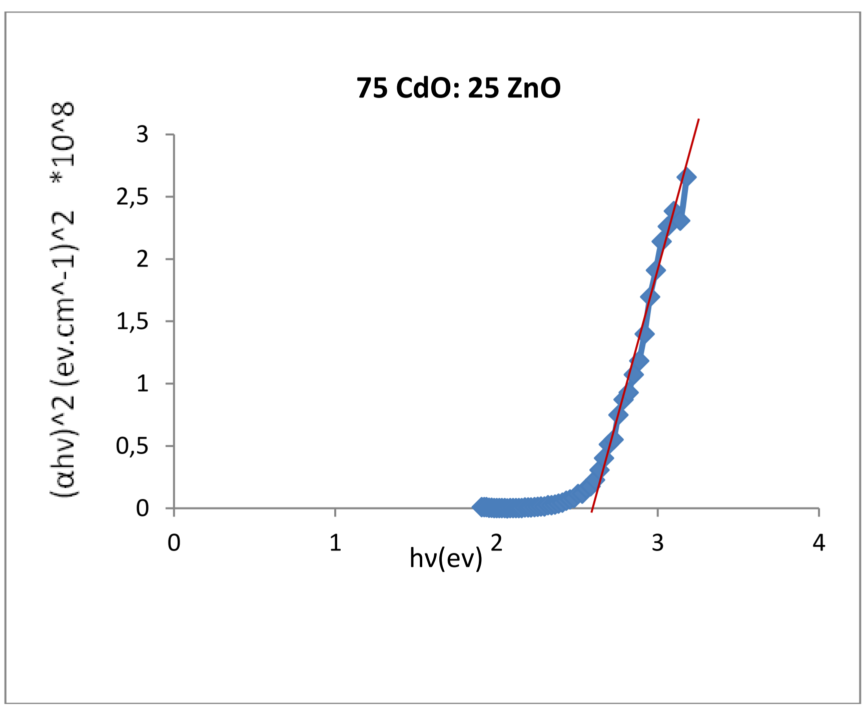
(b)


50 ZnO: 50 CdO
3,5
3
2,5
2
1,5
1
0,5
0
0
1
2
3
4
hν(ev)

(c)



(d)

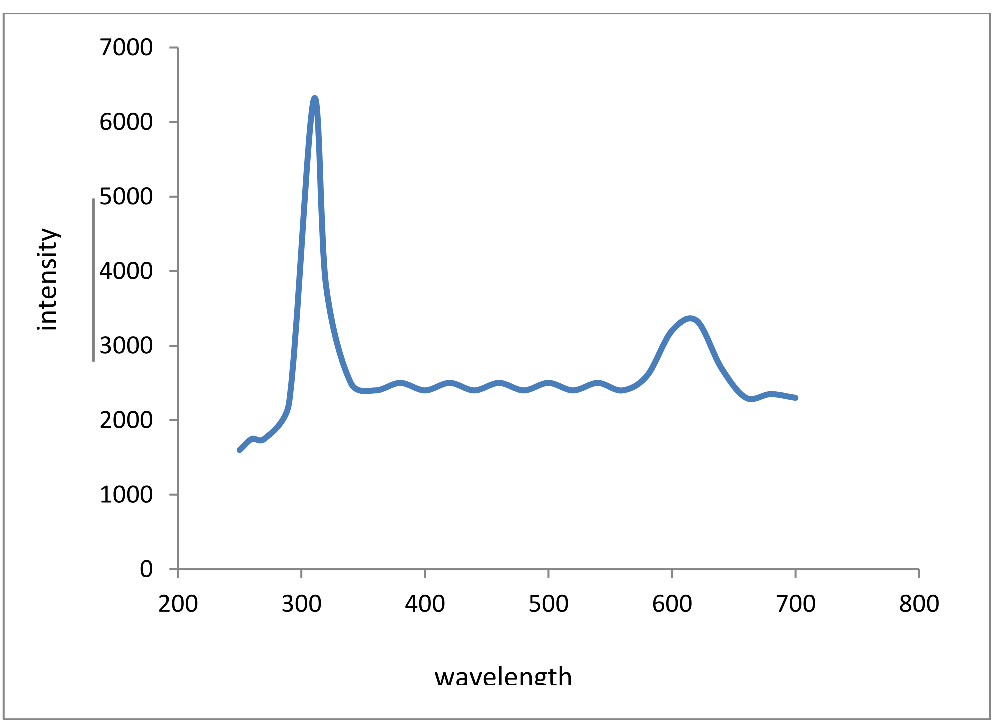


(e)

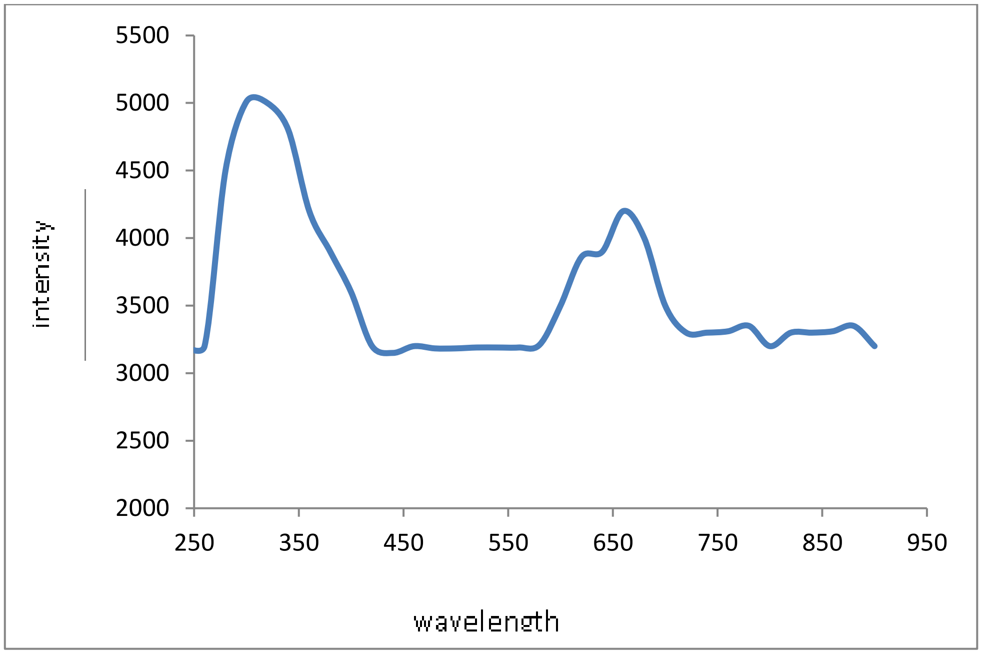
Fig. 2(a,b,c,d,e). Shows optical properties of ZnO-CdO nanocomposites.

Table 1. Structural properties of samples.

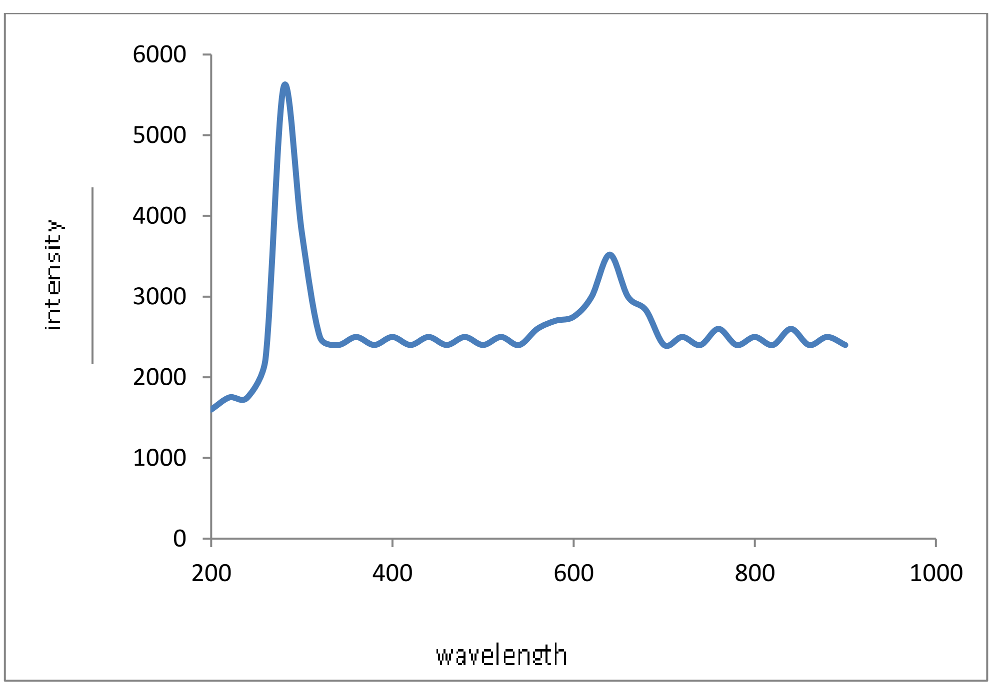
	ZnO pure	CdO pure	75 ZnO: 25 CdO	50 ZnO: 50 ZnO	75 CdO: 25 ZnO
Eg (eV)	3.2	2.3	3	2.9	2.6
d_{hkl} (nm)	0.26	0.235	0.2615	0.2717	0.21765
β (deg)	0.59	0.265	0.35	0.5467	0.17540
D (nm)	14.7	32.3	24.1	15.4	48.05
ε (* 10^{-3} $lines^{-2}$ m^{-4})	6.4	1.09	1.45	2.2	7.3



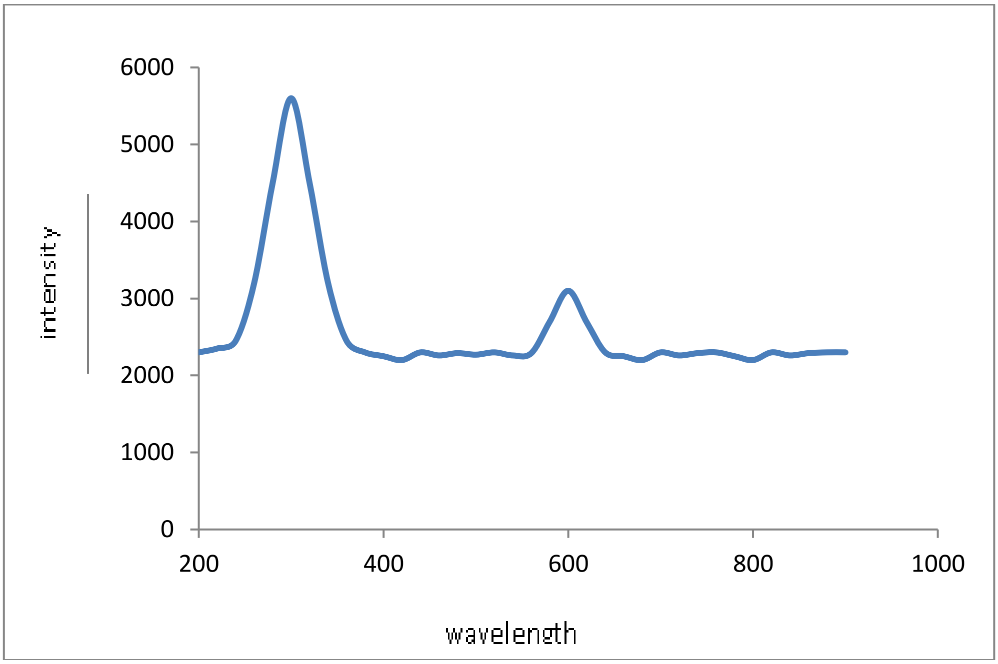
(a)


5500
5000
4500
4000
3500
3000
2500
2000
intensity
250
350
450
550
650
750
850
950
wavelength

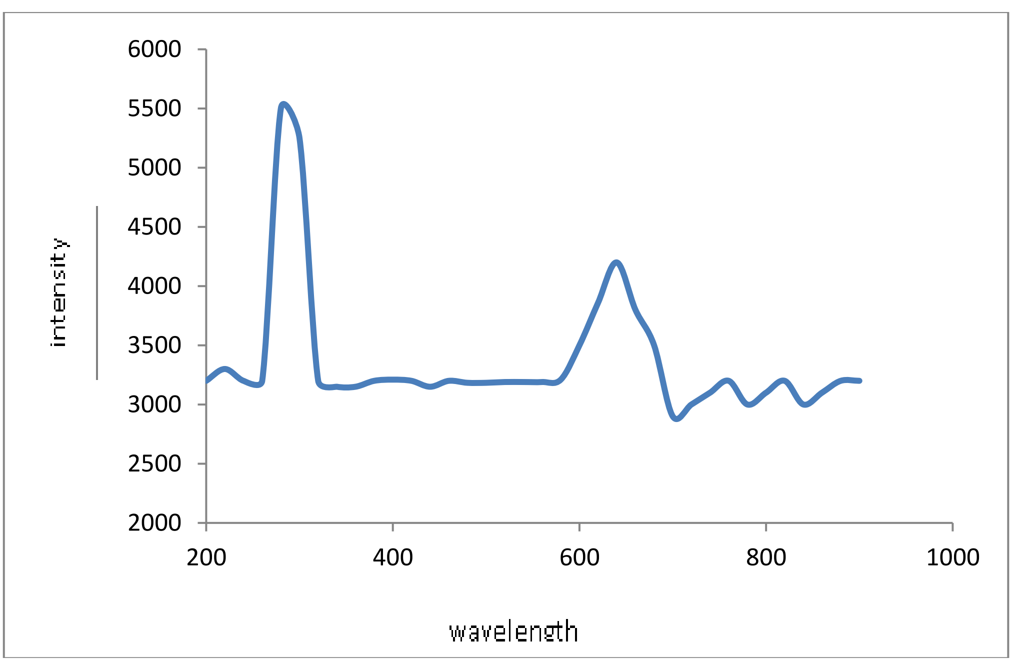
(**b**)


6000
5000
4000
3000
2000
1000
0
intensity
200
400
600
800
1000
wavelength

(**c**)



(**d**)



(**e**)

Fig. 3. Shows Fluoresence versa wavelength for (a) ZnO pure, (b) CdO pure, (c) 75 ZnO: 25CdO, (d) 50 ZnO: 50 CdO, (e) 75 CdO: 25 ZnO.

5. RESULTS AND DISCUSSION

Fig. (1) shows XRD structures for pure ZnO, pure CdO, 75 ZnO: 25 CdO, 50 ZnO: 50 CdO and 75 CdO: 25 ZnO .from the pattern can be noticed that preferential crystal orientation at 2ɵ = 36.3º for ZnO which exhibits (002), (100), (101), (110), (201) characteristic peaks of wurtzite hexagonal structure with average grain size (14.7) nm. While CdO pattern shows (111), (200), (220) with preferential crystal orientation at 2Ɵ = 33.02 with average grain size (32.3) nm with cubic structure.

The XRD data of ZnO-CdO nanocomposites showed major diffraction peaks at 2Ɵ = 32.9, 38.224, 55.2º due to existence of Cd species in ZnO samples according to ICDD card the intensity of(100), (101) remains unchanges with increment of CdO content while remarkable increment in preferred growth in (002) orientation with increase of CdO concentration.

The results showed from Figure (2) that there is a change in range of optical band gap from 3.2 eV for ZnO to 2.9 for CdO respectively leading to red shift for ZnO-CdO nanocomposites with the increase of CdO content and could be attribute to the existence of some Cd phase at the interphase of the nanocomposites. The violet emission is due to transition occurring from Zn interstitials (Zn_i) to the valence band while the green emission arises due to recombination of photo-generated hole and singly ionized oxygen. as it is well known that CdO has at least one indirect optical transition below the direct absorption edge at nearly 2.4 eV [11] .the weak PL peaks can be due to this indirect transition nature of the CdO structure. Therefore the PL peaks were noted to be close to ZnO [12].

6. CONCLUSIONS

Sol-gel method based on PVA as a conjunction can be used as a useful method to synthesize the CdO, ZnO & their nanocomposites due to low cost and simplicity. Structural and optical properties have been studied for ZnO-CdO nanocomposites with slightly red shift as CdO concentration increases. PL measurements indicates that the ZnO-CdO nanocomposites contain defects

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