Current Voltage (I-V) Characteristics of ZnS/PVK Nanocomposites

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Abstract: ZnS/PVK nanocomposites have been successfully prepared by chemical method. The optical and electrical properties of nanomaterials can be controlled by their particle size and therefore attracted much interest for their fundamental and applied aspects. The size of the particle was varied with different ZnS loading. The XRD pattern showed that the ZnS nanoparticles has zinc blend structure and line broadening suggests the formation of amorphous compound. The broadening of peaks tends to increase with decreasing ZnS loading showing decrease in particle size. The crystalline size is found to be in range of 03 to 10 nm. Absorption measurements reveal blue shifting of absorption edge from bulk ZnS. V-I studies show the linear relationship between current and voltage which indicates the ohmic nature that is there is ohmic contact between samples and electrodes. The impedance decrease as we increase frequency of applied voltage.

Keywords: - XRD, Absorption Spectra, ZnS, PVK.

I. INTRODUCTION

Poly N-vinyl carbazole (PVK) is a hole transport organic semiconducting polymer. It has been widely used as an electronic and optical material. ZnS is a well known inorganic and wide band semiconductor that has been a subject of considerable research due to its potential application in the areas of spin-electronics, opto-electronics, sensors, photocatalyst etc [1-4]. Previously, the nano composite of ZnS/PVK was prepared simply by mixing PVK and ZnS nano cluster or their precursors were prepared by simply mixing the synthesized nanoparticles with polymer. The effect of the inevitably introduced precursor molecules or the synthesized semiconductor nanoparticles is not clear to date, further more the conventionally synthesized semiconductor nanoparticles have a tendency to aggregate into larger clusters and their fine dispersion in the polymer is not very easy. Wang et al [5-7] has made a new approach for the preparation of truly two components ZnS/PVK nanocomposite. Khanna et al [8] have reported that the careful preparation of ZnS/CdS nanoparticles in DMF with metal rich surface can be considered responsible for stable light emission. This desire has promoted us to extend the synthetic methodology to functionalized and non- functionalized polymers. Polymers are considered a good choice as matrix materials for such purpose due to their long time stability and because they possess flexible reprocessibility. Present studies have been undertaken to synthesize ZnS/PVK nanocomposite with various loading of ZnS, characterize them by XRD, absorption spectra and investigated their I-V characteristics.

II. EXPERIMENTAL

For the synthesis of nanocomposite ZnS/PVK films, 400mg of poly N-vinyl carbazole (PVK) was dissolved in dimethylformaldehide (DMF) by constant stirring and heating at 80^oC temperature. Zinc acetate was added to the solution as 10, 20, 30 40 and 50% weight of PVK, so that ZnS loading in polymer equivalent weight. The resulting solution was stirred for 30 minutes. The solution was refluxed by applying nitrogen and then H_2S gased for a 30 second. The solution immediately turned milky white. Now again the solution was stirred for a few seconds. The chemical reaction as follows:

$$PVK + Zn(CH_3COO)_2 + H_2S \rightarrow ZnS/PVK + 2CH_3COOH$$

Then the solutions were caste over glass slides and conducting glass plates and were dried in an oven for several hours to obtain uniform film of ZnS/PVK nanocomposite. The films on plane glass slides were characterized by using Bruker D8 advance X- Ray diffractometer at IUC Indore. Optical absorption studies were performed by Perkin Elemer spectrometer. For study of I-V charecteristics, nanocomposites of ZnS/PVK thin film sandwiched between conducting glass plate and thin film of aluminium foil.

III. RESULTS AND DISCUSSION

XRD: The ZnS/PVK nanocomposites were characterized by X–ray powder diffraction which showed on perfect match with the diffraction pattern in the literature [9]. The X- ray diffraction patterns of ZnS/PVK nanocomposites of different size are shown in figure (1). The ZnS/PVK nanocomposite, shows considerable broadening in the X – ray pattern. This broadening of the diffraction peak is primarily due to the finite size of the nanocrysrallites. The diffraction peaks found at 2θ approximately 17.46^0, 28^0, 48^0 and 56^0. The diffraction peak at 2θ=17.46^0 corresponding to PVK. The other peaks at 2θ values 28^0, 48^0 and 56^0, matching the (111), (2 2 0) and (311) crystalline planes of cubic ZnS, indicated the formation of ZnS. The Debye–scherrer formula is used to approximately estimate the size of the nanoparticles [10-12]. The lattice spacing 'd' (2.25) is calculated from the Bragg's formula [13]. The lattice constant 'a' is also well matched with standard lattice constant 'a' (a=5.34). The interplaner distance'd' is also matched with standard 'd' of JCPDS data card (JCPDS 80-0020). According to the calculation the ZnS nano particle size for 10, 20, 30, 40, & 50% loading of Zinc acetate are found to be in range of 03 to 10 nm.

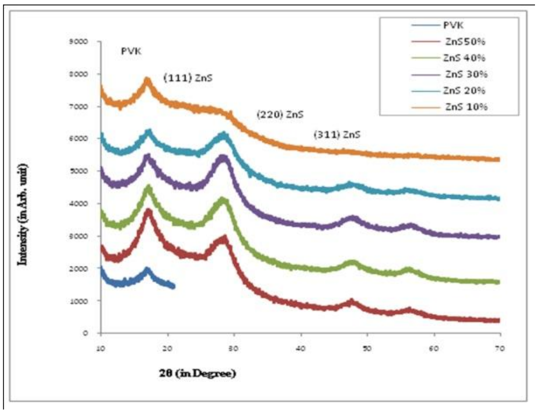


Fig. (1) XRD pattern of ZnS/PVK nanocomposites

Absorption Spectra: - Fig. (2) shows the UV/VIS optical absorption spectra in the range 200-550 nm for ZnS/PVK sample It is observed that there is negligible absorption in the range 800-500 nm, absorption increases at lower wavelengths. Sudden increase in absorption it observed in the UV region. The onset of absorption is obtained at 300, 305, 315, 327, 330 and 340 nm for 0, 10, 20, 30, 40 and 50% ZnS/PVK samples, respectively. The absorption spectra of the ZnS/PVK nanocomposites are basically a superposition of the absorption of pure ZnS nanoparticles and pure PVK.

As ZnS nanoparticle concentration in the composite increase, onset of absorption shifts towards higher wavelengths. The values of effective Eg are obtained as 4.13, 4.06, 3.93, 3.75 and 3.64 eV respectively for 0, 10, 20, 30, 40 and 50% ZnS loading in PVK. This indicates increased effective band gap and reduced particle size. The increase in the effective band gap of nanoparticles calculated by using effective mass approximation model. As the loa ding concentration of ZnS in PVK is increased the effective band gap is found to decrease indicating larger particle size. Particle size calculated from increased band gap energy using effective mass approximation model agrees with result obtained from XRD also.

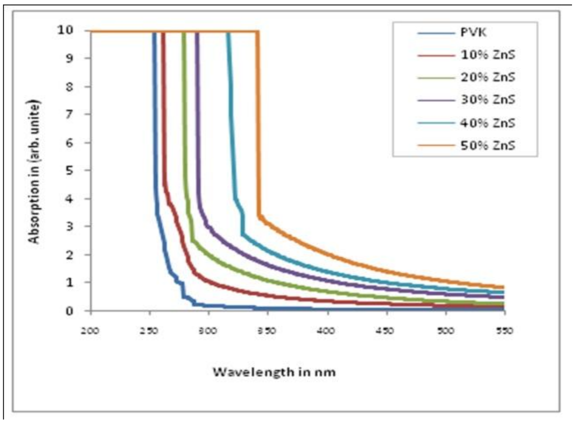


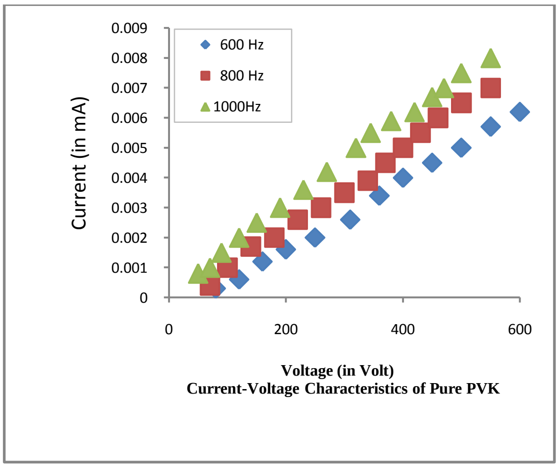
Fig. (2) absorption spectra of ZnS/PVK nanocomposites

Table 1 Particle size calculated from absorption edge and XRD

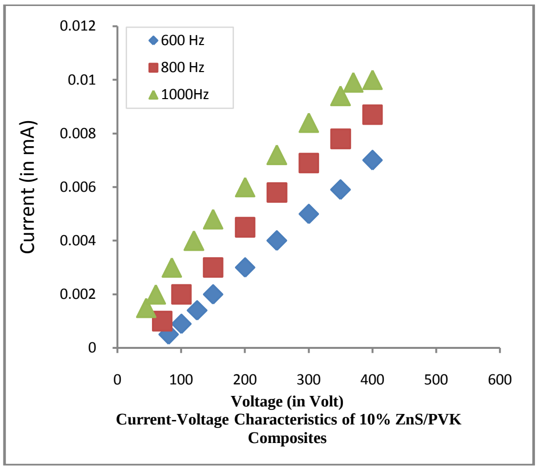
ZnS loading in PVK In (%)	Absorption edge wavelength	Energy band gap Eg (eV)	Particles size is determined (nm)	
			By absorption	By XRD
10%	305	4.06	3.34	3.2
20%	315	3.93	3.86	3.6
30%	327	3.79	4.62	3.9
40%	330	3.75	5.58	4.5
50%	340	3.64	7.9	7.9

Current Voltage Characterization

The voltage-current characteristics of ZnS/PVK composite films 0, 10, 20, 30, 40 and 50% ZnS loading in PVK for different frequencies are shown in Fig. 3(a), (b), (c), (d), (e) and (f) respectively. It is clear the graphs that:There is a linear relation between current and voltage. This indicates the ohmic nature that is there is ohmic contact between samples and electrodes.The slope indicates that, the impedance decreases as we increase the frequency. Ding et al. (2008) have also reported the linear relation between current and voltage [14] for CdS/PVK nanocomposites.



(a)



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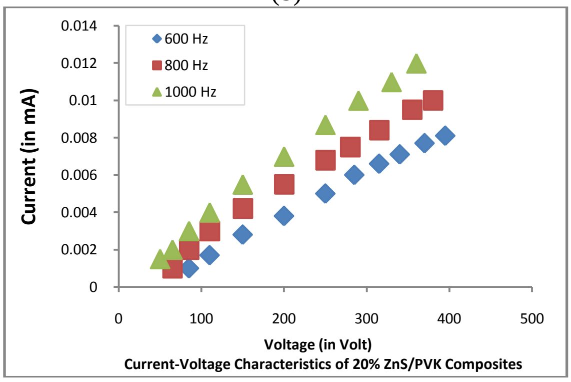
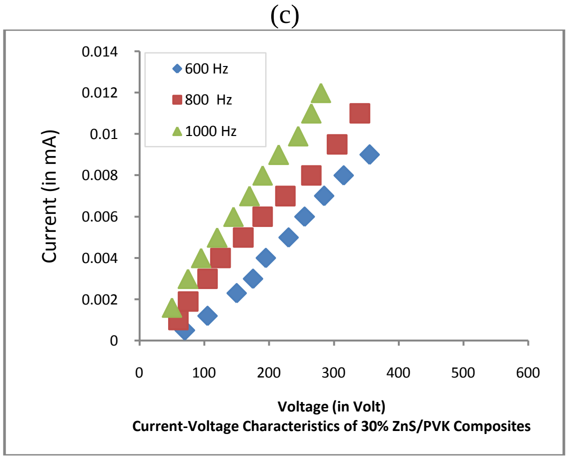
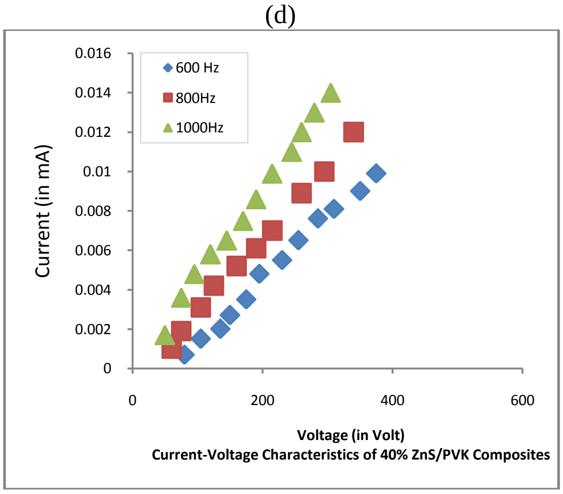


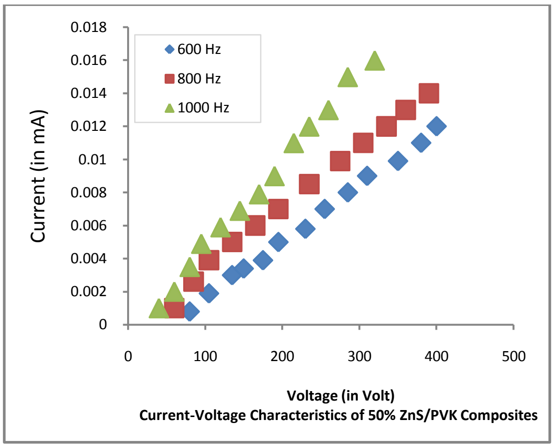
(c)



(d)



(e)



(f)

Fig. (3) Current-Voltage Characterstics of ZnS/PVK Nanocomposites

It is observed that slope of V-I curve increases with increasing the concentration of ZnS in PVK, showing that the impedance decreases as shown in fig. (4). Similar results are obtained for various frequencies.

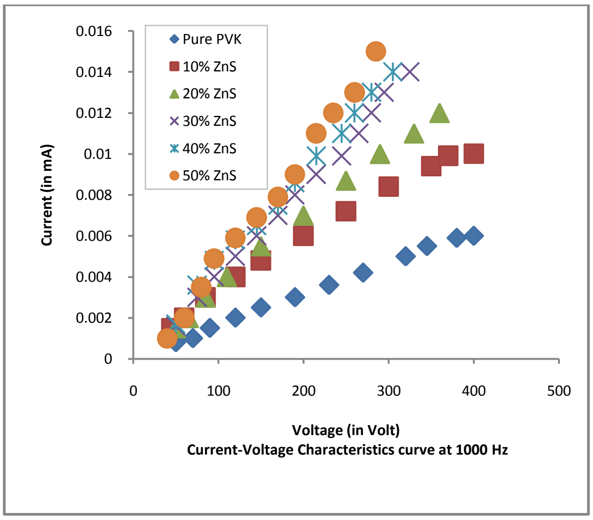


Fig. (4)

IV. CONCLUSION

The ZnS/PVK composite has been prepared by chemical method. XRD studies reveal that in the ZnS/PVK, ZnS crystals have cubic zinc blende structure. Crystalline sizes obtained by XRD using Scherrer's formula are of the order of 3 to 10 nm and found to increase by increasing ZnS concentration.

In the ZnS/PVK, composite the absorption edge is found in the range 200-400 nm, which is at lower wavelength as compared to bulk ZnS indicating increased band gap energy due to quantum confinement in smaller nanoparticles. Red shift is observed in the absorption edge with increasing ZnS loading. This may be consequence of quantum confinement effect due to larger crystal size for higher CdS concentration. I-V study shows the linear relationship between current and voltage which indicates the ohmic nature. The impedance decrease as we increase frequency of applied voltage.

V. ACKNOWLEDGMENTS

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VI. REFERENCES

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