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To Study The Mechanical And Electrical Properties Of Cds/PVK Nanocomposites

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Abstract:

We have fabricated new types of polymer nanocomposites by chemical rute method that is CdS/PVK polymer nanocomposites with novel organic/inorganic network structures. The poly N-vinyl carbazole (PVK) was used as a stabilizer as well as host matrix to prevent agglomeration of nanoparticles and have extraordinary optical, mechanical and electrical properties. The synthesize CdS/PVK nanocomposite thin films have been studies their electrical and mechanical properties. The microhardness study on pure PVK and CdS/PVK nanocomposites helps us to inter- and intra- molecular interactions. The CdS/PVK films exhibit lower value of microhardness as compare to pure PVK. For each CdS loading initially, the microhardness increases with the load and thereafter, beyond certain load, tends to attain a saturation value. The dielectric constant decreases at a faster rate in the low frequency range and after 50 KHz it remains almost constant for all samples. By increasing CdS concentration charge storage capacity is reduced which in turn, decreases dielectric constant. It is observed that the dielectric loss decreases with increasing the frequency and then become constant at higher frequency. It is also observed that loss factor increases with increasing CdS concentration in PVK. The conductivity of samples increases with increasing concentration of CdS in PVK matrix. In this case more charge carriers may be able to 'hop' by tunneling, which results in increase of bulk conductivity. The higher concentration of CdS makes the polymer more conductive.

1. Introduction:

Polymer nanocomposites composed of organic polymer and inorganic nanoparticles, have been widely investigated in the last three decades to develop new, value-added polymeric materials based on existing polymers [1–6]. To date, many Polymer nanocomposites consisting of various polymers and inorganic nanoparticles show significant improvements in some properties, such as electronics and photonics, modulus, heat-distortion temperature, hardness, gas impermeability and so on. Polymer nanocomposties can exhibit substantial property enhancement at extremely low filler content, reducing costs and weight of the final products. Poly-N-vinylcarbazole (PVK) is one of the attractive semiconducting polymers for electroluminescent and photorefractive devices. The chemical and thermal stabilities of PVK, combined with its excellent electrical properties, make it very useful in the electronic devices. The hole transport organic semiconducting polymer PVK has been generally used as an optical and electronic material. The CdS is an inorganic semiconductor and excellent materials for optoelectronic applications [7-12]. Cadmium sulphide (CdS) is an II–VI semiconductor material with a direct band gap of 2.42 eV at room temperature with many outstanding physical and chemical properties, which has promising applications in photochemical catalysis, gas sensors, detectors for laser and infrared, solar cells, nonlinear optical materials, luminescence devices and optoelectronic devices [13-16]. CdS also exhibited excellent visible light detecting properties [17]. In the last decades, many techniques have been reported on synthesis of CdS nanoparticles [18-20]. The optical and electrical and mechanical properties of nanomaterials can be controlled by their particle size and therefore attracted much interest for their fundamental and applied aspects. Present studies have been undertaken to synthesize CdS/PVK nanocomposite with various concentration of CdS in PVK and studies their property.

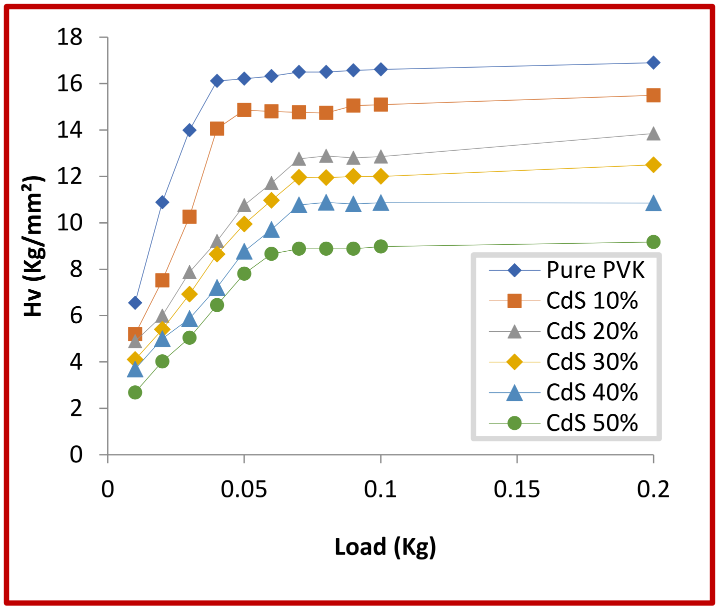
2. Synthesis of CdS/PVK nanocomposites

For the preparation of CdS/PVK nanocomposites, dissolved the 400 mg poly N vinyl carbazole in 15ml dimethyl formamide (DMF) at 80°C. In this solution, add the different concentrations of zinc acetate 10%, 20%, 30%, 40%, and 50% of 400 mg PVK. The obtained solution stirred was 30 minutes at room or normal temperature after applying H_2S gas for 30 second. This final solution was transferred to the plane glass plate and put in the oven for dry the sample in 6 hours at a temperature of 100^oC. The thin film of CdS/PVK nanocomposites has been obtained.

3. Mechenical Properties:

Microhardness : The different sample with various concentrations (0, 10, 20, 30, 40 and 50%) of CdS in PVK were prepared and subjected to the Vickers pyramid indentation. The Vickers hardness number (H_v) was calculated using equation $Hv=1.85L/d^2$, where L= applied load in Kg and d= arithmetical mean value of the measured diagonal lengths of the impressions in millimeters [21-22].

The variation of Vickers hardness number (Hv), as a function of applied load (in gms) is graphically shown in Fig. (1). As clearly seen in these figure, that the trend is similar for all samples. The value of Hv is higher for pure PVK and minimum for highest loading of CdS in PVK. For each concentration initially, the microhardness increases with the load and thereafter, beyond certain load, tends to attain a saturation value. The load at which H_V tends to saturate is same for all the samples (70gms). The initial increase in Hv as a function of load can be attributed to strain hardening phenomenon in polymeric materials [23-25]. On applying load, the polymer is subjected to some strain hardening. In the polymer chain, when there are sufficient number of active micro modes of deformation, large scale plastic deformation begins. With increase in load, greater strain hardening occurs and therefore Hv increases. Finally at higher loads, the sample is fully strain hardened and so no further appreciable increase in Hv occurs. When Hv value tends to become constant, the polymer is completely strain hardened. According to Amontons and Chery [24] phenomena, the microhardness may also be correlated with frictional force. The coefficient of friction decreases with increasing load and the frictional force is found to increase linearly with increasing load. Hence, the variation of Hv with load is curvilinear.



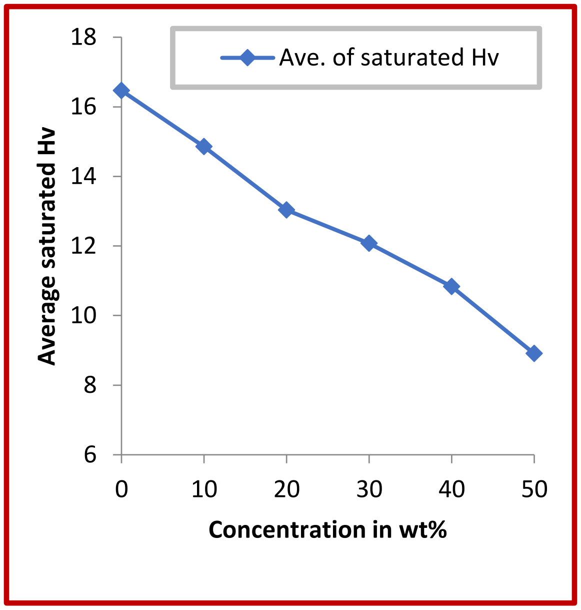


Fig. (1) Microhardness curves of CdS/PVK, Hv vs applied load for different wt% concentration of CdS in PVK.

Fig. (2)The curves average values of saturated Hv vs different wt% of CdS in concentration PVK.

Effect of CdS loading: Effect of CdS loading on the microhardness can be seen in fig. (2), which exhibit the variation of microhardness number Hv with different concentration of CdS in PVK. With increasing concentration there is a decrease in microhardness. The highest value of Hv is obtained for pure PVK.

Strain Hardening Index: The dependence of microhardness on load can be studied by the Meyer's law and two values n1 for lower loads and n2 for higher loads are obtain. It is evident that Vickers hardness (Hv) increases rapidly for the lower loads and then rate slows down for higher loads (saturation). For all the samples the value of Mayer index is greater than 2 indicating that surface is softer that deeper layers.

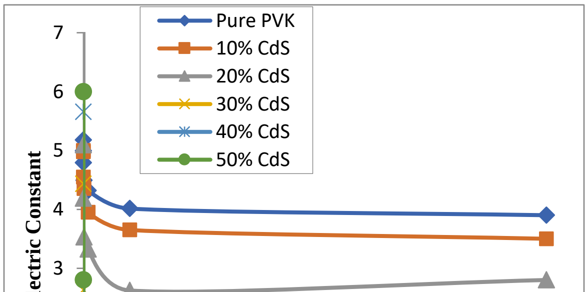
Table (1) Different calculated values of (n) for different wt% loading of CdS in PVK.

Sample name	CdS loading in PVK In (%)	Slope	
		Low load region	High load region
CdS/PVK - I	0%	3.1	3.0

CdS/PVK - II	10%	3.4	2.7
CdS/PVK – III	20%	3.8	2.4
CdS/PVK – IV	30%	3.9	2.3
CdS/PVK – V	40%	4.1	2.2
CdS/PVK - VI	50%	4.3	2.1

4. **Electrical Properties:** Electrical properties of the sample were investigated and dielectric constant, dielectric loss and conductivity were computed.

Dielectric Constant: The dielectric constant of the composites is also a function of its capacitance, which is proportional to the quantity of charge stored on either surface of the sample under an applied electric field. Fig.(3) shows the variation of dielectric constant of pure PVK and different loading concentration of CdS in PVK at room temperature with frequency in the range 1-10^5 Hz. As evident from fig (3) the dielectric constant decreases at a faster rate in the low frequency range and after 50 KHz it remains almost constant for all samples. In the low frequency region, the charge on defects can be redistributed such that defects closer to the positive side of the applied field become negatively charged, while defects closer to the negative side of the field become positively charged. This leads to a screening of the field and an overall reduction in the electric field results. Since capacitance is inversely proportional to the field, the reduction in the field for a given applied voltage results in an increase in dielectric constant as the frequency is lowered. As the frequency is increased, the charges on the defects no longer have time to rearrange themselves in response to the applied voltage. Thus the dielectric constant remains almost constant for wide frequency range. Similar results have been also obtained previously Kuo et.al. and Maxwell et. al. [26-27]. In CdS/PVK nanocomposites, increasing the concentration of CdS in (PVK), the quantity of the accumulated charges will decrease because of reduced permittivity of CdS/PVK nanocomposites. From this point of view the dielectric constant of the pure PVK is higher than the CdS/PVK composites. By increasing CdS concentration charge storage capacity is reduced which in turn decreases dielectric constant.



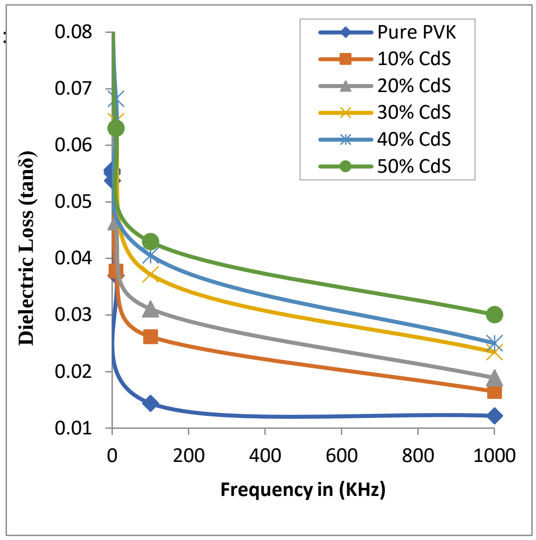


Fig. (3) **Fig.(4)**

Dielectric Loss (tanδ):- The dielectric loss is the power dissipated in a dielectric as heat when the dielectric is exposed to an electric field. Dielectric loss (tanδ) is defined as a ratio of energy lost or dissipated per cycle to the energy stored. It was measured directly using dielectric spectroscopy. Fig (4) represents the dielectric loss versus frequency of pure PVK and different concentration of CdS in PVK.

It is observed that the dielectric loss decreases with increasing the frequency and then become constant at higher frequency. It is also observed that dielectric loss increases with CdS concentration. The growth in tanδ and thus increase in conductivity is brought about by an increase in conduction of residual current [28].

A.C. Conductivity: - Fig. (5) Shows the conductivity of pure PVK and variation of conductivity with filler (CdS) concentrations. The increase in conductivity with increasing concentration of CdS may be attributed to the conductive phase formed by dispersed CdS in polymer matrix. It is known that electrical conductivity of such composites depends on the concentration of the dispersed compound. The increase in conductivity is related to a possible increase in the number of conduction paths created between the CdS particles aggregate in composite in addition to a decrease in the width of potential barriers within the bulk regions of high conductivity. Therefore, more charge carriers may be able to “hop” by tunneling, resulting in the increase bulk conductivity and it also increases with increasing CdS concentration [29-31]. The higher concentration of CdS to make the polymer more conductive. Generally, enhancement in a.c. electrical conductivity by increasing filler contents is attributed to electronic interaction processes taking place in the composites.

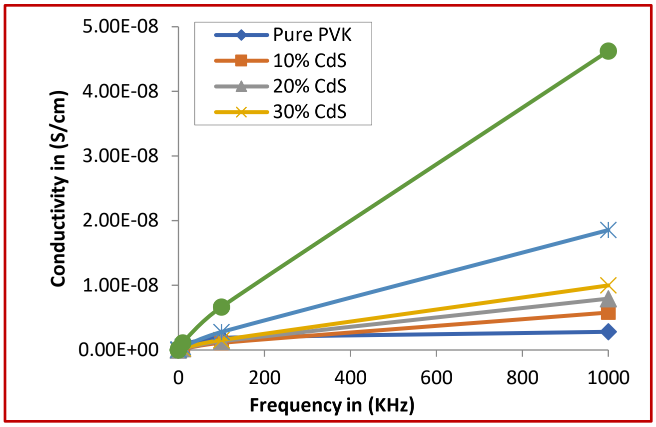


Fig.(5)

5. Conclusions:

The CdS/PVK nanocomposites were prepared using chemical technique for different concentrations such as 10, 20, 30, 40 and 50% of CdS loading in PVK. CdS/PVK nanocomposite films have been studies their electrical and mechanical properties. The microhardness study on pure PVK and CdS/PVK nanocomposites helps us to understand the modification in properties due to inter- and intra-molecular interactions. It is seen that CdS/PVK films exhibit lower value of microhardness as compare to pure PVK. For each CdS loading initially, the microhardness increases with the load and thereafter, beyond certain load, tends to attain a saturation value, where one can say that the samples are fully strain hardened at this load. The dielectric constant decreases at a faster rate in the low frequency range and after 50 KHz it remains almost constant for all samples. By increasing CdS concentration charge storage capacity is reduced which in turn, decreases dielectric constant. It is observed that the dielectric loss decreases with increasing the frequency and then become constant at higher frequency. It is also observed that loss factor increases with increasing CdS concentration in PVK. The conductivity of samples increases with increasing concentration of CdS in PVK matrix. In this case more charge carriers may be able to 'hop' by tunneling, which results in increase of bulk conductivity. The higher concentration of CdS makes the polymer more conductive.

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7. References

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