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Optoelectronic Properties *of* ZnS and CdS Nano-Composites and their Applications

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ABSTRACT

UV-Vis spectrum of PANI, CdS and ZnS nanoparticles and their composites with different weight % have been recorded on double beam spectrophotometer in the wavelength range 150-1000 nm to measure band gap and particle size of materials. It is generally noticed, that nano particles made of semiconducting elements change their optical properties in comparison to their bulk materials and a significant shift in optical absorption spectra towards blue region is noticed. The absorption band observed in the UV-Vis spectra of samples is recorded with corresponding optical band energies. The energy band gap and particle size of CdS and ZnS along with their nano composites are calculated from UV- Vis spectra and recorded simultaneously. On the basis of recorded data it is observed that, there are two absorption maxima, one in the UV region and other in the visible region for PANI. The fine structure absorption measures in the range 200-300 nm corresponding to absorption peaks, the band gap was calculated to be 2.61eV for CdS, which is larger than that of corresponding bulk material reported to be 2.40 eV. It is also observed that composites containing 5% and 10% show the enhanced absorption spectra as compared to other composites of different weight percentage simultaneously. In case of PANI-ZnS nanocomposites, two absorption bands are observed at 300 and around 550 nm coincide with those of pure PANI spectra. UV-Visible spectra of PANI-ZnS infers that particle size of nanoparticles of CdS is 3.8 nm and that of ZnS is 3.92 nm. The blue shift in absorption maxima and increased band gap of the synthesized CdS and ZnS confirms the formation of nano sized inorganic semiconductors. The calculated values of particle size and band gap energy of materials reveal the variation of opto-electronic properties. This study leads to develop the basis of photo chromic sensors and solar cell applications.

Keywords: UV-Visible spectroscopy, Semiconductor nano-composites, Energy band gap, Photo chromic sensors, Solar cell.

INTRODUCTION

Semiconducting nano-composites exhibit electrical and optical properties leading to wide range of technological applications. The unique properties of conducting polymers like stability, elasticity, plasticity, hardness, strength, thermal stability, insulation, conductivity not only provide great scope for their opto-electronic applications but also have led to the development of new models to explain their observed properties. This work tends to study the conducting polymers in which Poly-aniline (PANI) is most tenable member which can be used in sensors and electro chromic devices. We have also considered II-VI semiconductor nano material's, as they possess large variation of band gap as function of particle size which is a consequence of quantum confinement and has vast applications in solar cells, fluorescent materials and photonic research [**1, 2**]. The work reported here includes UV-Visible (UV-Vis) spectrographs used to study the structure and stability of materials. Various kinds of electronic excitations may occur in organic molecules by absorption of energies available in UV-Vis region. It is generally noticed, that nano particles made of semiconducting elements change their optical properties in comparison to their bulk materials and a significant shift in optical absorption spectra towards blue region is noticed [**3-5**].

Nano composite materials have emphasized significantly, to encompass a large variety of systems, such as one-dimensional, two dimensional, three dimensional and amorphous materials, made of density dissimilar components and mixed at the nano meter scale. The general class of Nano composites organic/inorganic matter is a fast growing area of research. Nano composite materials lead to new and improved properties when compared to their Nano-composite counterparts. Therefore, Nano composites promise new applications in many fields, such as mechanically reinforced light weight components, non-linear optics, battery cathodes, nano wires, sensors and other systems. In the past few years, new fillers have emerged, providing an opportunity for the development of high performance multifunctional Nano composites.

The conductivity of the conducting polymer can be tuned by electrical manipulation of the polymer backbone by the nature of dopant, by the degree of doping, and by making composites with inorganic materials [**6, 7**]. When conducting polymers are taken in the composite form, their properties are altered from those of basic materials. It has been shown that the conductivity of these heterogeneous systems depends on number of factors such as the concentration of the conducting fillers, their shape, orientation and interaction between filler molecules. The geometrical shape of the dispersant governs the ability of conductive network formation which results in large increase in conductivity. The physical properties of the matrix of concern elements influence the agglomeration of the dispersant phase which affects the properties of composites.

The size of silicon nanoparticles decreases, the band gap changes and the colour of the particle changes [**8**]. Another example is single wall carbon nanotubes which can exhibit stiffness, strength and strain that statistically exceed that of traditional micrometer diameter carbon fiber. These features of nanoparticles provide an opportunity for creating polymer composites with unique properties.

The study of semiconductor nanoparticles has been interesting field of research for more than two decades. This is because; it provides an opportunity to understand the physical properties in low dimensions and to explore their vast potential for various applications. The unique feature of semiconductors is based on the large variation of the band gap as the function of particle size, which is a consequence of quantum confinement. Nanostructured materials specially II-VI semiconductors has been a subject of intensive research for their extra ordinary properties compared to their bulk counterpart. Blue shift of the optical absorption spectrum, size dependent luminescence enhances extra strength. Particularly, semiconducting materials in the nanostructured form offers the possibility of possessing large optical nonlinear susceptibility and the ultrafast response. They are very attractive for the realization of the thermally stable and frequency selective lasers and photo detectors, whose performance is found to be modulated drastically by the shape and size of the nano-crystals.

It was considered II-VI semi-conductor materials ZnS and CdS and has been reported in this piece of paper. These materials have been attracted considerable interest in recent years due to their vast applications in various fields including solar cells, fluorescent materials, optoelectronic devices, spintronics, photonic research etc [9, 10]. Therefore it is thought worthwhile to synthesize CdS and ZnS Nanoparticles and make their composites with conducting polyaniline.

MATERIALS AND METHODS

The data for spectrum of PANI-CdS and PANI-ZnS nanoparticles and their nano-composites with different weight percentage were recorded on double beam spectrophotometer in the wavelength range 150-1000 nm to measure band gap and particle size of materials. The absorption band observed in the UV-Vis spectra of samples is recorded and corresponding optical band energies are also measured. The absorption band observed in the UV-Vis spectra of samples is recorded with corresponding optical band energies. The energy band gap and particle size of CdS and ZnS along with their nano composites are calculated from UV-Vis spectra and recorded simultaneously.

RESULTS AND DISCUSSION

Figure 1 and 2 shows that, there are two absorption maxima, one in the UV region and the other one in visible region. The fine structured absorption in the range 200-300 nm corresponding to absorption peaks and broadens around 480-600 nm. The observed peaks thus confirm that prepared PANI is in conducting form doped with SO_4. The band gap was calculated to be 2.61eV for CdS which is larger than corresponding bulk material which is reported to be 2.40 eV. It is also observed that large variation is observed in the intensity of absorption. It is also noticed that composites containing 5% and 10% CdS shows the enhanced absorption as compared to other composites. Similarly, absorption spectra of synthesized ZnS show the maximum absorption band at 300 nm which indicates the blue shift in absorption maxima as compare to bulk material. The particle size of ZnS was found to 3.81 nm calculated from the absorption band. In case of PANI-ZnS nanocomposites, two absorption bands at 300 and around 550 nm are observed and coincide with those of pure PANI as shown in adjacent figures. The particle size of CdS nanoparticles was found to be 3.8 nm and that of ZnS was found to be 3.92 nm.

Conclusively, the blue shift in the absorption maxima and increased band gap of the synthesized ZnS and CdS confirms the formation of nano-sized inorganic semiconductors of CdS and ZnS. These results are in consistent with TEM images as observed by other workers [11, 12]. Thus, from the above electronic spectra of the synthesized polymer and its composites, it is also been concluded that the blue shift in absorption maxima and increased band gap of the synthesized CdS and ZnS confirms the formation of nano-sized inorganic semiconductors. Thus as a result following conclusion can be drawn:

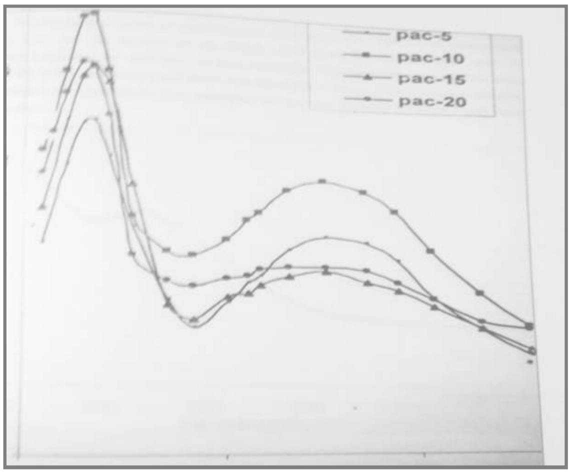

Figure 1. UV-Vis spectra of PANI CdS nanocomposites.

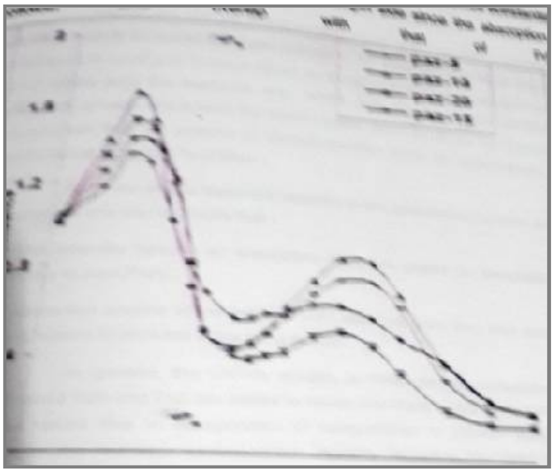

Figure 2. UV-Vis spectra of PANI ZnS nanocomposites.

(1) The intensity spectra of absorption increases greatly in composites as compare to pure PANI. (2)Absorption spectra of synthesized CdS and ZnS show blue shift indicating the formation of particles in the nano region. The calculated values of particle size and band gap energy of materials confirm the variation of opto-electronic properties.

APPLICATION

This work tends to study the conducting polymers in which Poly-aniline (PANI) is most tenable member which can be used in sensors and electro chromic devices and is a consequence of quantum confinement and has vast applications in solar cells, fluorescent materials and photonic research. This study also leads to develop the basis of photo chromic sensors and solar cell applications.

CONCLUSION

On the basis of recorded data, it is observed that there are two absorption maxima, one in the UV region and other in the visible region which varies at different weight percentage of dopant. The blue shift in the absorption maxima and increased band gap of synthesized ZnS and CdS confirms the formation of particles in the nano region. The computed values of particle size and band gap also confirm the variation of optoelectronic properties.

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