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Comparative Electro- and Photo-Luminescence Study of Selenium based Chalcogenide Nanocomposite with PVA Matrix

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Abstract - Chalcogenide nanocomposites are synthesized by various techniques here we prepared selenium based chalcogenide nanocomposites by environment friendly simple chemical route. Here PVA is used as surfactant and stabilizer for nanoparticles, it also protects nanoparticle from photo-oxidation. Here we have studied the Electroluminescence (EL) and Photoluminescence (PL) in CdSe/ PVA, ZnSe/ PVA and an intermediate state CdZnSe/ PVA. In the EL Study we found the EL peaks at 605nm 536 nm 480nm for CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA respectively. PL peaks observed at 595 nm, 544nm and 433 nm for CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA respectively. EL and PL both study show Spectral shift towards lower wavelength when we are approaching from CdSe/PVA to ZnSe/PVA.

***Key Words*:** Chalcogenide Nanocrystals, Electroluminescence, PVA based nanocomposite, and Photoluminescence

1. INTRODUCTION

In periodic table almost all elements in the VIA group are called chalcogens. Class of metal chalcogenides is highly varied and can be classified in many different ways [1]. These are sulfides, selenides, tellurites, and double, triple, quartet, and multiple chalcogenides by the number of elements. In this study we have used only selenides. Chalcogenide composites have been studied extensively for optical properties. There is a great interest in II–VI semiconductor nanoparticles, particularly organically capped soluble particles of cadmium or zinc sulphide and selenide, for their ready to use application in devices. For electroluminescence (EL) devices, it is expected to cover a broad spectrum and to tune various specific colours by preparing $Cd_{1-x}Zn_x$ Se instead of CdSe and ZnSe[2]. Chalcogenide nanocomposites are studied with doping of metals and rare earth elements. It is found that electroluminescence in Chalcogenide nanocomposites depends on doping of Ag [3]. Chalcogenide semiconductor nanomaterials with improved and unanticipated properties are unusual materials that will continue to precept the pace in the field of science and technology [4].

2. Synthesis of CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA

CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA nanocomposites were prepared by simple chemical route. Cadmium chloride $CdCl_2.2H_2O$ and $ZnCl_2.2H_2O$ were chosen as metal ion source, sodium selenosulfate (Na_2SeSO_3) was chosen as the selenium source, and polyvinyl alcohol (PVA) was chosen as the stabilizer. No additional stabilizer was needed because the high viscosity of the polymer solution prevented the particles from aggregating. Chemical reaction of sodium selenosulfate and metal source $CdCl_2.2H_2O/ZnCl_2.2H_2O$ was performed by stirring for 3 hours to obtain a resultant solution at 90 degree temperature, during the reaction concentration of PVA is fixed. Using same method CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA nanocomposites were obtained. Photographs of obtained resultant solutions after chemical reaction and after coated on plane glass slides are shown in figure 1. Visibly, red color is obtained for CdSe/ PVA, CdZnSe/ PVA shows light red color and and ZnSe/ PVA shows brownish transparent color.

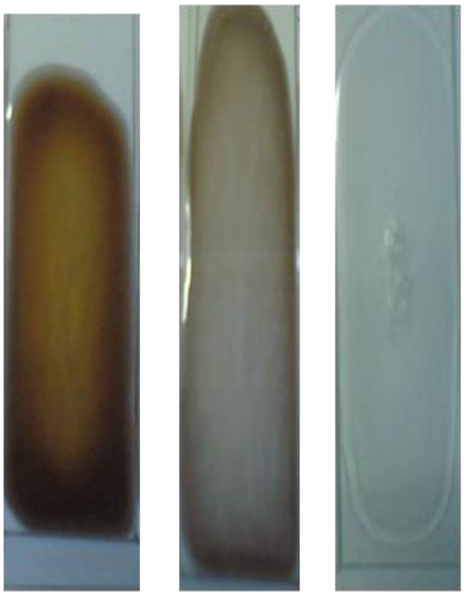

Figure 1: CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA nanocomposites

3. STRUCTURAL CHARACTERIZATION

The structural characterization of PVA based nanocomposite films were performed by an X-Ray diffractometer (Rigaku rotating anode H-3R) using Cu K_α radiation taken from 10^0 to 60^0. The chalcogenides of Cd as well as Zn normally shows the duality in their crystal structure. They can be formed with either sphalerite (Cubic, zinc blend type) or wurtzite (hexagonal type) structure [5, 6]. The X-ray diffraction (XRD) spectra of CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA nanocomposites films deposited on glass substrate are shown in Fig. 2. XRD pattern of pure PVA cast on glass slide is shown in the inset of figure. PVA is well known as a crystalline polymer and the diffraction peak at 2θ =19.6 corresponds to the PVA crystalline phase. In the XRD of CdSe/ PVA nanocomposite, it appears sample is having hexagonal phase with peaks at 2θ =23.53, 25.01, 27.03, 35.20, 41.90, 45.88, and 49.70

correspond to (100), (002), (101), (102), (110), (103) and (112) planes.

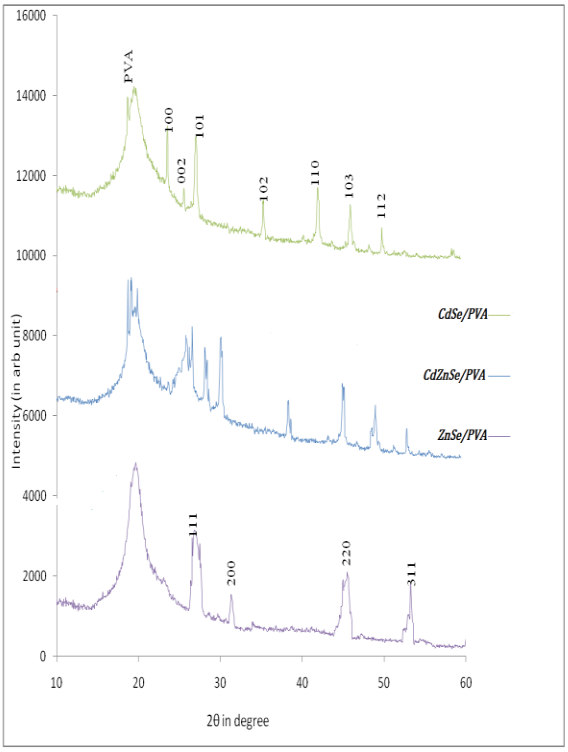

Figure 2: XRD pattern of CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA nanocomposites

In ZnSe/ PVA nocomposite we observe peaks correspond to cubic structure (111), (200), (220), (311). But in case of CdZnSe we observe hexagonal peaks with shifting from original position it may be due to incorporation of Zn Metal ions replacing Cd ions.

4. ELECTROLUMINESCENCE (EL) STUDY

Electroluminescence (EL) study was performed under Voltage- brightness characteristics, voltage current characteristics and EL spectra analysis. In case of voltage brightness characteristics, there is a specific voltage at which sample starts to show the EL phenomenon i.e. gives response in form of light, is known as threshold voltage of EL emission. On applying alternating supply light emission starts at threshold voltage then it may increases with increasing voltage; it depends on the nature of sample. Voltage brightness curves for synthesized nanocomposites are shown in figure 3 at frequency 800 Hz.

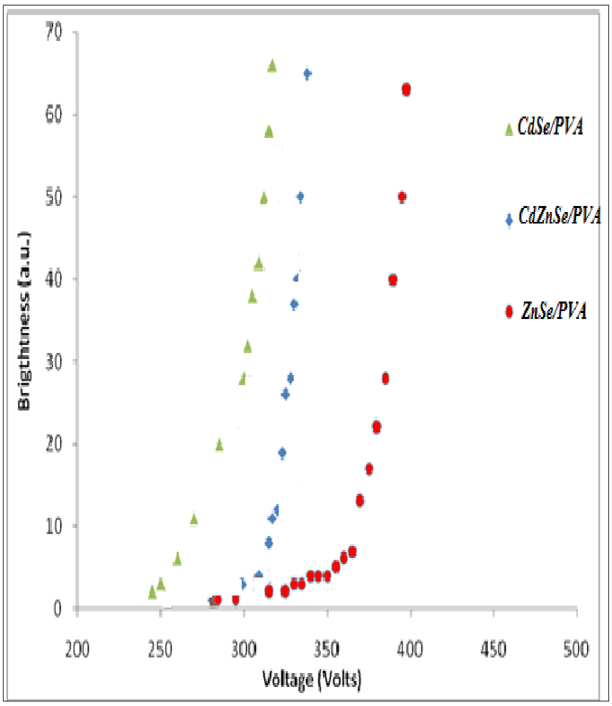

Figure 3 V-B Characteristics of CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA nanocomposites

It is seen that as the applied input voltage across the EL cell increases, the emission starts at a particular voltage and increases rapidly. By increasing the applied electric field, injection of electrons and holes from cathode and anode is enhanced, i.e., in emitting layer more electron and hole pair are created. Due to the fact that electron- hole pair recombine immediately and emit more photons, the electroluminescence intensity or brightness increased. The turn on voltage was found in between 275 volts to 380 volts.

Figure 4 shows voltage current characteristics curves for all samples. It is clear from graphs that there is a linear relation between current and voltage. The linear relation between current and voltage indicates the ohmic nature, that is, there is ohmic contact between sample and electrodes. Liyun et al [7] have also reported the linear relation between current and voltage in CdS/PVK nanocomposite film.

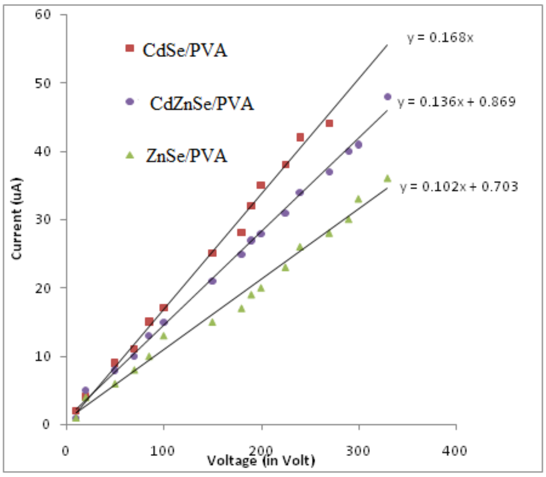

Figure 4 V-I Characteristic Curves of Nanocomposites

It can be seen from the figure that slopes of V-I curve decreases, when we are approaching towards ZnSe/PVA from CdSe/PVA. Consequently impedance of sample increases. A general increase in impedance may be due to increase in the band gap of the nanocrystalline films.

Figure 5 shows EL spectra of nanocomposite film at 900 Hz frequency, it is clear from the figure that in EL experiments no PVA emission is observed. This indicates that charge carriers that are injected from metal electrodes recombine solely at the metal selenide particles. This can be understood if the particles act as trap for at least one type of charge carrier and the transport is hopping between these traps. Emission peaks in electroluminescence of nanocomposite films are found at 605, 536 and 480 nm for CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA respectively.

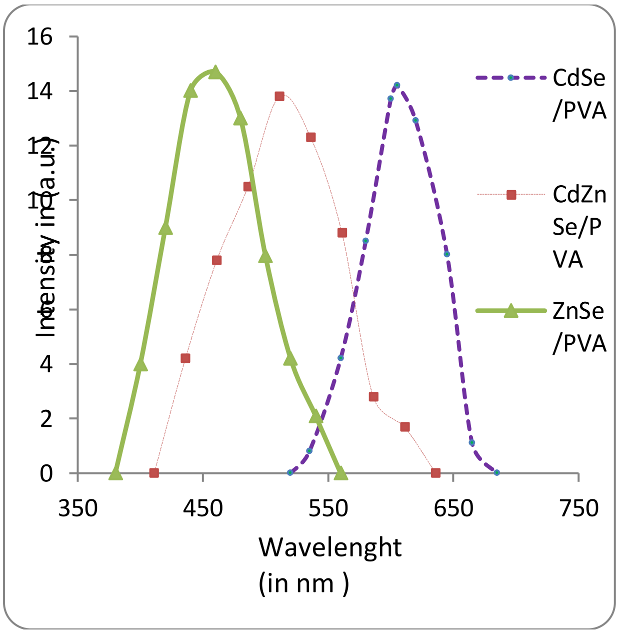

Figure 5: EL Spectra of CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA Nanocomposites

5. PHOTOLUMINESCENCE (PL STUDY)

Figure 6 shows PL spectra of three samples. Photoluminescence excited by 410 nm. PL emission peaks are found at wavelength 595, 544, and 433 nm for CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA nanocomposites respectively. In the PL spectra band edge luminescence was not detected.

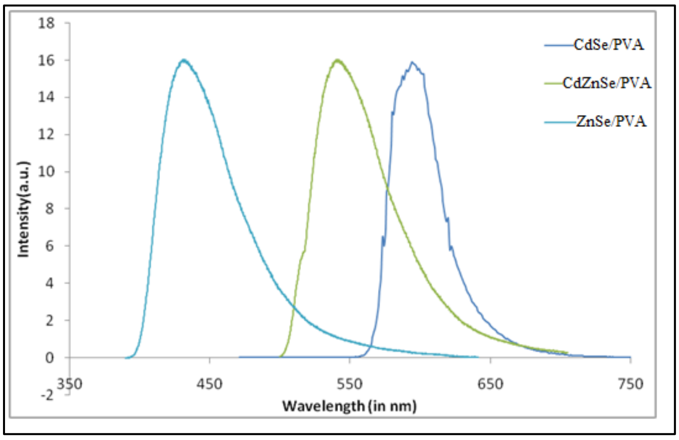

Figure 6: Photoluminescence Spectra of CdSe/ PVA, CdZnSe/ PVA and ZnSe/ PVA nanocomposites

6. CONCLUSION

Selenium based chalcogenide nanocomposites nanocomposite films have been prepared environment friendly single step solution method using poly vinyl alcohol as polymer matrix. XRD study reveals that CdSe/ PVA was found in hexagonal phase and CdZnSe/ PVA was found in same phase with a little shift in angle value but ZnSe/PVA was found in cubic phase.

From photoluminescence study shifting of PL emission peak in shorter wavelength when we are introducing Zn metal source. PL was observed for defect related transitions for our Selenium based chalcogenide nanocomposites. Electroluminescence studies show that required turn on voltage is lower for CdSe/ PVA than ZnSe/PVA. The voltage-current curve represents ohmic nature of the EL cell. The increase in EL intensity was faster for higher frequency. Single EL peak at 605 nm have been obtained for CdSe/ PVA and systematic blue shift takes place on introducing Zn metal source nanocomposite. Similar phenomenon was observed in case of photoluminescence spectra.

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