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*Research Article*

## **THE INVESTIGATION ON ELECTRICAL AND OPTICAL PROPERTIES OF CdO/CNT NANOCOMPOSITE**

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### **ABSTRACT**

In this study, composite materials reinforced with carbon nanotubes (CNT) containing cadmium oxide were produced and investigated optical and electrical properties of them. Carbon nanotubes which used support materials were synthesized by chemical vapor deposition. After then, they were reinforced in to the cadmium oxides which were sold by commercial. As another group, cadmium oxides were synthesized by sol-gel method and reinforced carbon nanotubes with different rate. Synthesized CNT's were subjected to TEM investigation. Obtained CNT's were also subjected to SEM as structural. After those, gained composite samples were investigated for both electrical conductivity, changing temperatures and optical properties by UV-vis spectrometers. It was clear, as a result that electrical conductivity was increased by raising CNT rates for both groups. Beside composites containing CdO, synthesized by sol-gel method have higher conductivity than composites containing CdO bought by commercial have. To sum up, CdO composites synthesized by sol-gel have both higher conductivity and optical properties comparing with commercials have.

**Keywords:** Carbon Nanotube, Cadmium Oxide, Composite

## 1. INTRODUCTION

Cadmium oxide is used in metal-matrix semiconductor technology. Solar cells, gas sensors, liquid crystals and smart screens, optical heater and LED (Lighting Emission Diode) are the most important usage areas (Soylu *et al.*, 2015). CdO is the one of the important semiconductor in which metal-oxides field for optoelectronic devices (Gullino *et al.*, 2005). Owing to crystal structure and oxygen vacancies, CdO is an n-type semiconductor (Haul *et al.*, 1962). Both scientist and engineers are interested in due to 2.2 eV band gap (Ristic *et al.*, 2004; Jayakrishnan *et al.*, 2003). High transparency in visible lights, high conductivity in room temperature (Ristic *et al.*, 2004),  $10^{19}/\text{cm}^3$  (Zhou *et al.*, 2007) electron concentration, and also high mobility  $\mu=130\text{cm}^2/\text{V.s}$  (Cruz *et al.*, 2005) are became CdO special part of semiconductors. CdO can be produced for several different methods, for examples, chemical bath sediment deposition, sol-gel, sputtering, spray pyrolysis, solid liquid vapor.

After the discovery of CNT (Carbon Nanotube) by Iijima (1991), CNT was attracted scientist and manufacturer's attention due to its usability to several disciplines. The controllability at the nanoscale for materials led us to show different characteristics (Siegel *et al.*, 1999). These characteristics are played a huge role in different and wide industrial applications for instance high-strength composites, bioscience, nanoscale semiconductors and hydrogen storage (Saito *et al.*, 1998; Baughman *et al.*, 2002). Possession of excellent flexibility, very low density and having high conductivity (Wang *et al.*, 2013; Xining *et al.*, 2014) make CNT's application areas are diversified. Graphene has 1600 – 2400 GPa approximately Young Module, 120 – 140 GPa Tensile Strength and  $2 \times 10^5 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$  approximately Carrier Mobility. These all are 270 – 950 GPa, 11 – 150 GPa respectively for Multi Walled Carbon Nanotubes and 1000 GPa approximately, 13 – 53 GPa,  $0.79 - 1.2 \times 10^5 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$  respectively for Single Walled Carbon Nanotube (Xining *et al.*, 2014).

The method studying with obtained CdO commercially is very widespread. Besides this method, the new another method that gained nanoscale material by using Sol-Gel is gaining popularity. Sol-Gel is an advantageous method that emerges because of the traceability of morphologic and dimensional control of nano-sized materials to be synthesized (Wang *et al.*, 2013). Another advantage of this method is not only production of metal matrix materials, but also can be using production for organic-inorganic hybrid materials.

In our study, the C group samples stand for obtained CdO commercially, the S group of samples stand for gained CdO with Sol-Gel method. These groups are given a chance comparing with commercial CdO and Sol-Gel CdO.

## 2. EXPERIMENTAL

In this study, CdO was used as matrix material. Acros Organic brand (Code: 223792500, 99 % purity). The CNT used as a dopant was synthesized by Chemical Vapor Deposition (CVD) method. A single-crystal Silicon mat (100) was used in the CNT synthesis. Firstly, the mat was washed with acetone in ultrasonic bath. Secondly, washed

mat was washed again with ethanol in the same media. After the bath process, the mat was placed in middle of a tube furnace, on a button. The inside of the tube furnace was evacuated with a pump and was free of air. After those, was heated to 650 °C and Ar gas was used during the heating period. The Ar gas was given the system with 1 lt flow rate. Once tube furnace was 650 °C, cut the flow of Ar gas and acetylene gas ( $\text{C}_2 \text{H}_2$ ) was given for 40 minutes. The end of the 40 minutes, the flow of acetylene was cut down and Ar gas was given again until furnace temperature was down to room level.

First of all, CNT was added in to CdO which was obtained commercially, as 0.2, 0.5 and 1 % w. For the production of composite, carbon nanotubes gauged in a beaker in the appropriate weight and added alcohol on it. To a homogenous mixture alcohol carbon nanotube mixture was stirred in an ultrasonic stirrer and then added in appropriate amount of CdO. The fish is mixed magnetic stirrer until alcohol was evaporates. The resulting powder mixture was pressed into pellets at a pressure of 600 MPa and then was sintered at 450 °C. Code name is given to samples and they are shown in Table 1.

The structure of obtained composites was determined with Scanning Electron Microscope. Jeol Jsm 7001 F brand was used in this study. Electrical conductivity of the composites was measured using two-probe method with the help of Keithley 6517A Electrometer/High-Resistance Meter. Optical measurements of the samples were performed using a Shimadzu UV-3600 PC UV-VIS spectrophotometer.

Table 1. Code name of samples

Code	Composition of samples
C0	Pure commercial CdO
C1	0,2% CNT – CdO composite
C2	0,5 % CNT – CdO composite
C3	1 % CNT – CdO composite

## 3. RESULTS AND DISCUSSION

Fig. 1. a, b and c show SEM images for Pure CdO, % 0,2 CNT – CdO and % 1 CNT – CdO samples, respectively. As seen from these images, the homogeneous distribution in composite of CNTs were increasingly difficult with the increase in the CNT quantity of composite. In 0.2 % CNT reinforced specimen, CNTs were seldomly disitubed to structure. This state was arised from relatively few of CNTs quantity. Also, CNTs were homogenly disitubed to structure. Furthermore, In 0.1% CNT reinforced specimen, CNT bundles were completely dissolved. As seen from SEM images of 1 % CNT reinforced specimens, dissolve of CNT bundles and disperse of CNTs in strucure were relatively limited. In 1% CNT reinforced composite, CNTs wrap up alike a cobweb on CdO grains. In certain regions, it was seen that no CNTs bundles were dissolved and remain as cluster. In study, The common features of all CNT reinforced specimens are that shortening of CNTs length were occurred. This state arise because of applied ball milling in order to disperse uniformly in structure and applied mild sonication in order to dissolve the CNT bundles. Breaking of CNTs was occurred during these processes.

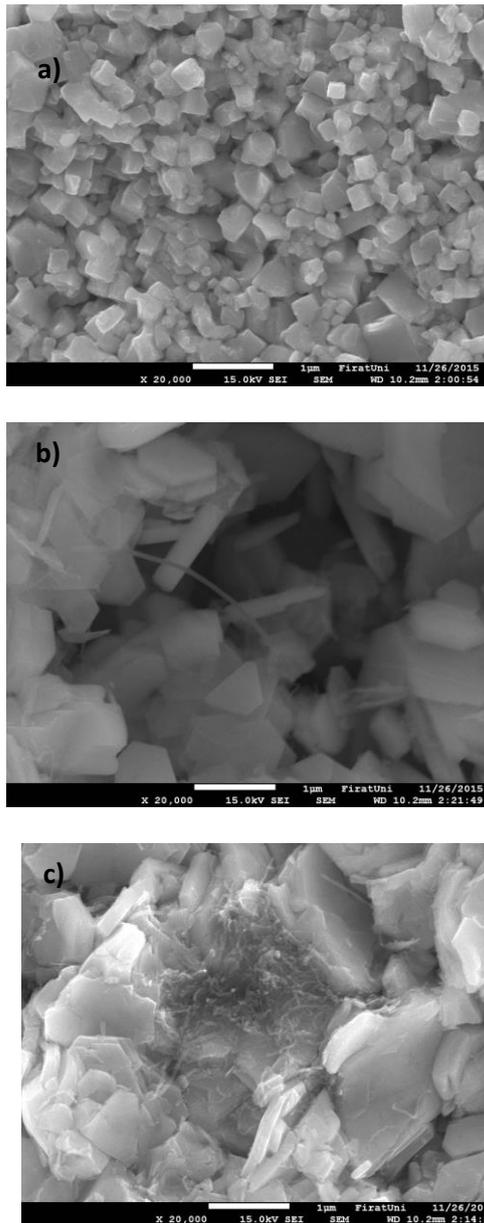


Fig. 1. a) Pure CdO b) 0.2 wt % CNT c) 1 wt % SEM images of the composites

The electrical transport operation of CNT-CdO composites were studied by the temperature dependent conductivity. As seen in Fig. 2, the electrical conductivity of the composites increases with increasing temperature. But, electrical conductivity of pure CdO is constant with increasing temperature. It is observed that the conductivity of the CdO based composite increased with increasing CNT content. The reason of the increase in conductivity with the increase in temperature is due to the loaded carriers exceeding the activation energy barrier of the CdO based composites. Elevated temperatures cause an increase in the number of charge carriers involved in electrical conduction (Güler *et al.*, 2015).

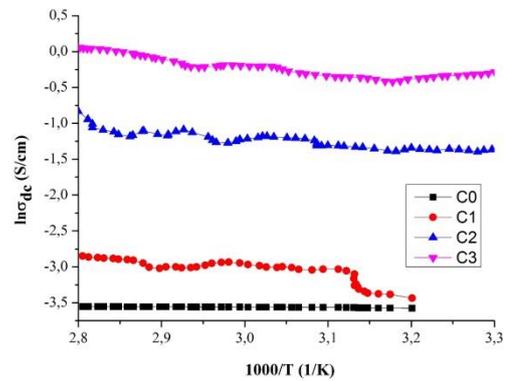


Fig. 2. Plots of the electrical conductivity versus temperature of the CNT-CdO nanocomposites

Fig. 3 show the plots of the diffused reflectance for undoped and CNT-reinforced CdO composites, respectively. The reflectance of the 0,2%, 0,5% and 1% CNT reinforced specimens point out a rise at 300 nm, 310 nm, 295 nm, respectively. The reflectance of the composites is firstly increased, then decreased with CNT contents. But, composites reflectance values decrease in comparison with pure CdO. The decrease in reflectance is due to the increase in absorbance of the composites. Additionally, the change in reflectance of the samples with CNT dopants is resulted from the surface and the internal reflection effects of the composites, because, when CNT into composite is added, it changes the color and surface properties of the composite. As a result the absorption of the samples is increased and the reflectance is reduced depending on the amount of CNT.

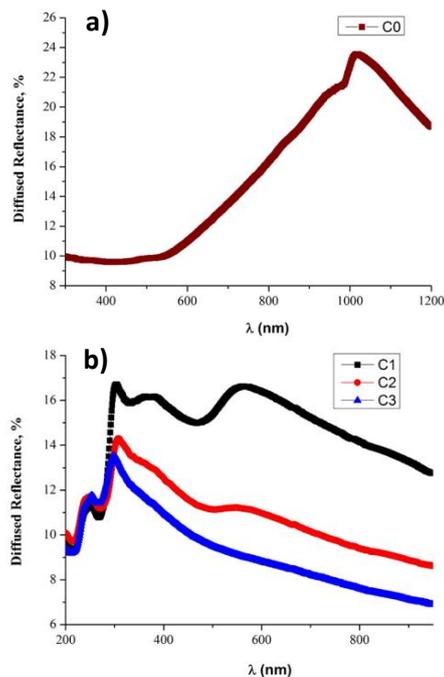


Fig.3. The reflection spectrum of (a) undoped and (b) CNT-CdO nanocomposites

The optical band gaps of the composites were determined by optical reflection method based on Kubelka-Munk for the analysis of diffuse reflection spectra. The Kubelka-Munk theory is obtained for the analysis of diffuse reflectance spectra from a weak absorptive sample. The reflection spectrum of the compounds shows that the composites prepared are a gently absorbing material. The Kubelka-Munk function can be expressed by the following formula (Aydin *et al.*, 2011).

$$F(R) = \frac{(1-R)^2}{2R} \quad (1)$$

Here,  $F(R)$  is the Kubelka-Munk function corresponding to the absorbance and  $R$  is the reflection. The reflection spectrum of undoped and CNT-CdO nanocomposites are shown in Fig.3. To determine the optical band gaps of composites, the reflectance values were converted to absorbance. The Kubelka-Munk function is used for this. As a result, the relationship used to determine the optical band gaps of conventional semiconductors is as follows (Yakuphanoglu *et al.*, 2009).

$$F(R)h\nu = A(h\nu - E_g)^n \quad (2)$$

Where  $A$  is a constant and  $E_g$  is the optical band gap,  $n$  is a constant exponent which determines the type of optical transitions. The optical band gap of the composites was determined from the plots of  $(F(R)h\nu)^2$  versus  $h\nu$ , as shown in Fig. 4.

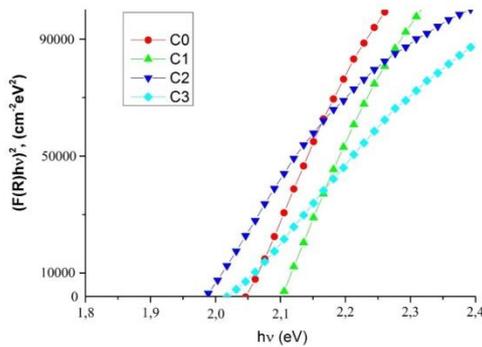


Fig. 4. Plots of  $(F(R)h\nu)^2$  versus the photon energy ( $h\nu$ ) of the CNT/CdO nano-composites.

Accordingly, the values of band gap of C group samples are changed to in Table 2. According to the table, while there was a decrease between C0 and C2 samples, an increase in C3 was observed.

Table 2. Band gap of C group samples

C Group	$E_g$ (eV)
C0	2,05
C1	2,1
C2	1,99

## CONCLUSION

As a result, CdO-CNT composites have been successfully produced. Homogeneous distribution in the CdO becomes more difficult by increasing the number of nanotubes. The electrical conductivity of the composites increased by increasing the amount of CNT and temperature. The optical absorption of the composites is around 295-310 nm. The optical band gap of samples is decrease with CNT contents.

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