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Effects of Zno on electrical properties of Polyaniline Composites

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ABSTRACT
In the present investigation, Polyaniline / Zinc oxide with various weight percentage of Zinc oxide (10%, 20%, 30, 40% and 50%) were synthesized by in-situ polymerization method. The prepared composites were characterized by X-Ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Fourier Infrared Spectroscopy (FTIR). The dc conductivity of the samples was measured as a function of temperature in the range 30-180^oC and it was found that increasing the concentration of ZnO particles increases the conductivity. Ac conductivity of the composites was studied with respect to frequency.
Keywords: Composites, Electrical properties, SEM, XRD, FTIR.

I. INTRODUCTION

Composites and blends based on conducting polymers (CP's) have recently emerged as a new class of potentially useful materials. A great deal of work is being done by many groups all over the world to understand and engineer their exceptional electrical, optical and chemical properties Recently nanocomposite materials have become one of the most extensively studied material all over the world as they have shown to possesses several technological application such as effective quantum electronic devices, magnetic recording materials sensors etc.[1]. Moreover nanocomposite material composed of conducting polymers & oxides have open more field of application such as drug delivery, conductive paints, rechargeable batteries, toners in photocopying, smart windows, etc [2, 3]. Polyaniline (PANI) is one of the most interesting CP's, which is a suitable choice for various applications, such as, in solar cells, sensors, electromagnetic shields and rechargeable batteries' electrodes. Additionally, it is also known for its easy preparation methods and environmental stability [4, 5]. Because of these unique properties, it has attracted special attention among all the CP's in the recent years. Electrical conductivity of PANI can be significantly modified by suitable doping. For example, doping PANI with malonic acid increases its conductivity by an order of magnitude [6]. Similarly, nanocomposites made of PANI and montmorillonite show a variation in room-temperature conductivity as much as eight to nine orders of magnitude depending on the PANI content [7]. Semiconductor nonmaterial has been received great attentions. Among these various semiconductors oxide nonmaterial zinc oxide is a versatile material because of its physic-chemical properties such as mechanical, electrical, optical, magnetic and chemical sensing properties. It has a wide band gap of 3.3 eV and it is used in various applications of electronic devices, biomedical field, variety of sensors, etc [8-12]. In this paper, the author has reported Pani/ZnO composites, which were synthesized by in-situ polymerization method. These composites were characterized by using Fourier transform infrared spectroscopy (FTIR), X-Ray diffraction (XRD) analysis, Scanning Electron Microscopy (SEM) and also studied the electrical properties of prepared composites.

II. SYNTHESIS OF POLYANILINE/ZNO COMPOSITES

Synthesis of the PANI/Zinc oxide composites was carried out by in-situ polymerization method. Aniline (0.1 M) was mixed in 1 M HCl and stirred for 15 min to form aniline hydrochloride. Zinc oxide particles were added in the mass fraction to the above solution with vigorous stirring in order to keep the Zinc oxide homogeneously suspended in the solution. To this solution, 0.1 M of ammonium persulphate, which acts as an oxidizer was slowly added drop-wise with continuous stirring at 5°C for 4 h to completely polymerize. The precipitate was filtered, washed with de-ionized water, Acetone, and finally dried in an oven for 24 h to achieve a constant mass. In this way, PANI– Zinc oxide nanocomposites containing various weight percentages of ZnO (10 %, 20 %, 30 %, 40 %, and 50 %) in PANI were synthesized.

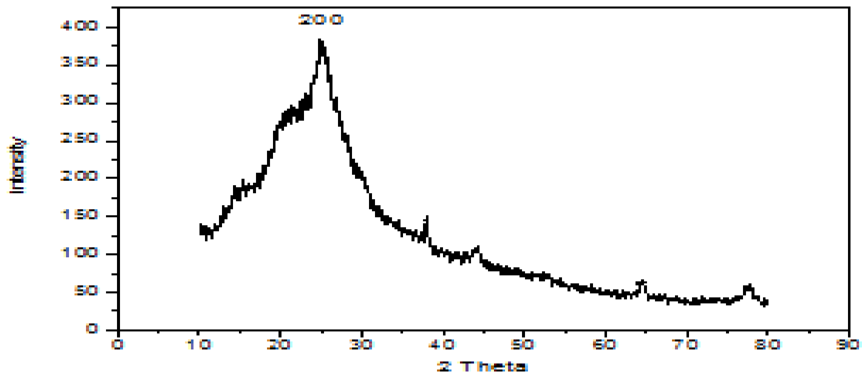
III. CHARACTERIZATION

X-ray diffraction studies were performed using Philips X-ray diffractometer with CuK_α as the radiation source. The morphology of the Zinc oxide and composites in the form of powder was investigated using SEM Model-EVO-18 Special Edison, Zein Germany, Fourier transformed infrared spectra of these composite were recorded on Thermo Fisher ATR Nicolet model using diamond (iS5) in the range 4000-400cm-^{1}.DC conductivity of these composites are also studied by using Keithley 6514 electrometer, Frequency-dependentac conductivity were measured by employing LCR meter Newton Model PSM-1735.

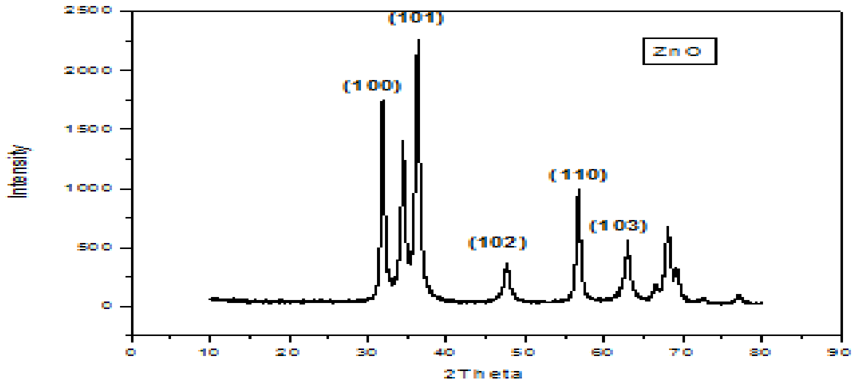
IV. RESULT AND DISCUSSION

4.1 X-ray diffraction

a) Polyaniline



b) ZnO



c) Polyaniline /ZnO Composites

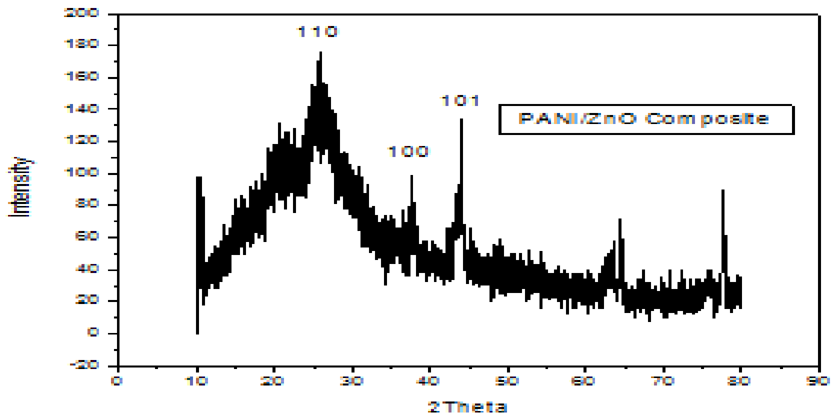


Figure 4.1 shows XRD spectra of (a) Polyaniline, (b) Zinc oxide and (c) Pani/ZnO composites**.**

Figure (a) shows X-ray diffraction pattern of Polyaniline. A broad peak centered at 2θ at 25.53^{0} may be assigned to the scattering from the polyaniline chains at interplanar spacing which clearlyimplies the amorphous nature of polyaniline and it corresponds to (200) diffraction planes of pure Polyaniline .Figure b&c shows the XRD pattern of pure ZnO, and Pani/ZnO composite The .The XRD diffraction peaks of ZnO powder are shown in a good agreement with hexagonal structure reported in JCPDS File Card (No.05-0664).The intensity of diffraction peaks for Pani/ZnO composite are lower than that for ZnO.The presence of amorphous PANI reduces the percentage ratio of ZnO and sequentially weakens diffraction peaks of ZnO.

4.2 Fourier Infrared Spectroscopy

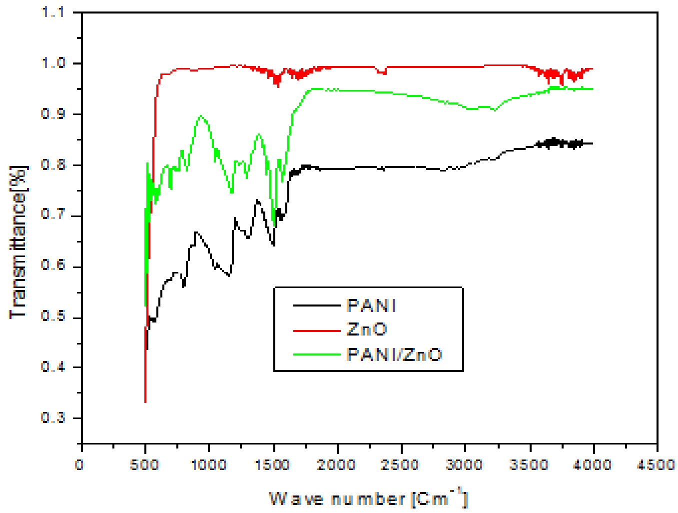
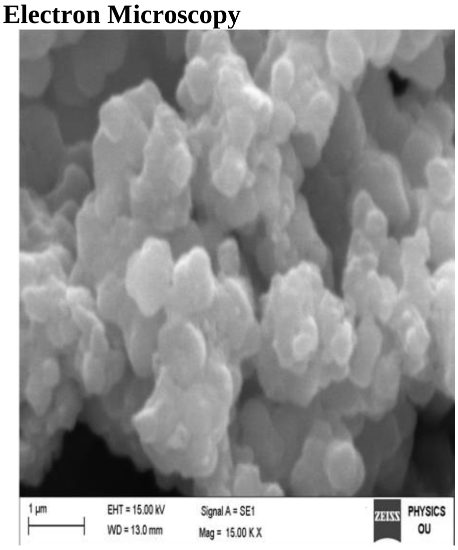


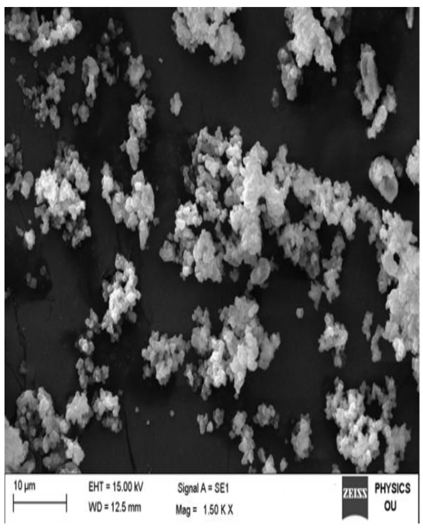
Figure 402 shows FTIR spectra of a) Polyaniline, b) Zinc oxide and c) Pani/ZnO composites**.**

The FTIR spectra measurement was carried out to study the molecular bonding of the PANI and PANI/ZnO composites (ZnO 50 wt % in PANI). Figure 4.2 (a,b&c) shows the FTIR spectra of the pure PANI, ZnO and PANI/ZnO composites. For the pure PANI Fig. (a), the characteristic peaks appear at 1564 cm $^{-1}$ due to C=C stretching of quinoid rings, 1475 cm^{-1} due to stretching of the benzenoid ring, which conforms the formation of polyaniline. Figure shows that the FTIR spectra of pure Zinc oxide and it has predominant peaks at 2336 cm^{-1} and 1550 cm^{-1} conforms the formation of Zno compounds. And Figure shows the spectra of polyaniline/ Zno composites. It is observed from the figure that a large broad bands appears at 3397cm^{-1} which is due to the O-H Stretch because of absorption of water molecule ,the peaks 1565 cm^{-1} corresponds to C-N Stretching of Quinoid rings,1493 cm^{-1} is due to C-N-Stretching of benzenoid rings The peaks at 1297 cm^{-1} is due to vibration band of the dopant anion ,1113cm^{-1} is due to –C-H in plane bending vibration.The peaks from 881 to 680 cm^{-1} is due to Alkene C-H bending,the peaks from 582 to 508 cm^{-1} is due to Hydrogen interaction composite .

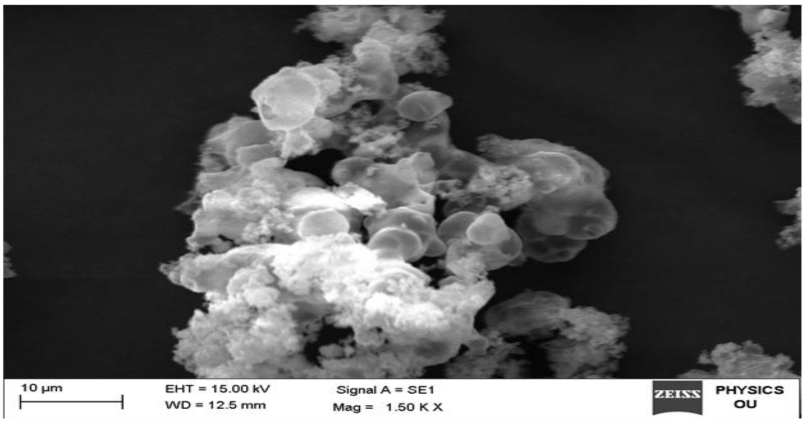
4.3 Scanning Electron Microscopy



PANI



ZnO



polyaniline /ZnO Comosites

Figure 4.3 shows the SEM Image of (a) Polyaniline, (b) Zinc oxide and (c) Pani/ZnO composites**.**Figure 4.3 (a–c) shows the scanning electron micrograph (SEM) of polyaniline, Zinc oxide, and PANI/ZnO composites (ZnO 50 wt % in PANI). The SEM performed on these samples indicate that the transformation of highly branched-like polyaniline which have granular-like structure were ZnO particle is highly agglomerated ZnO in PANI (10, 20, 30, 40, and 50 wt % of ZnO in PANI), increases the granular size and decreases the porosity. The SEM image also reveals the presence of ZnO in polyaniline which is homogeneously distributed throughout the polymer sample.

V. DC CONDUCTIVITY

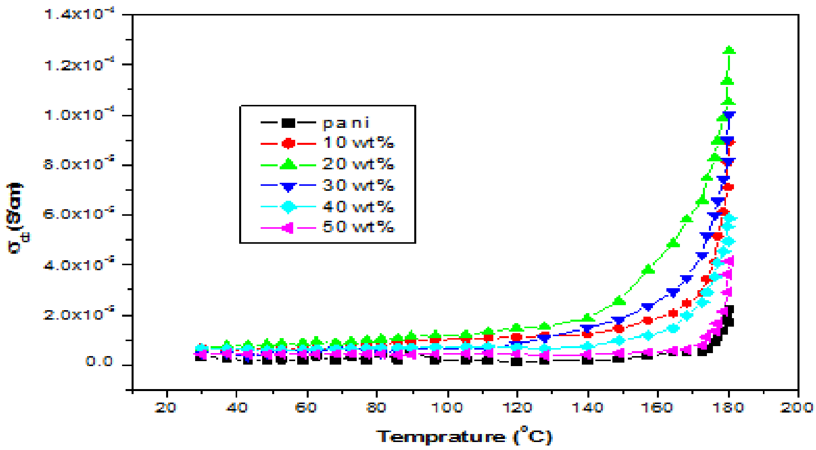


Figure 5 shows the variation of Dc conductivity Vs/Temperature

Electrical conductivity

The in-situ oxidation polymerization method can be a general and useful procedure to prepare conductive polymer and its composites. It is well established that the charge transport properties of conjugated polymers strongly depend on the processing parameter . Polyaniline has a reactive N-H group in a polymer chain flanked on either side by a phenylene ring, imparting a very high chemical flexibility. It undergoes protonation and deprotonation in addition to adsorption through nitrogen, which having lone pair of electrons, is responsible for the technologically interesting chemistry and physics. The plot of surface d.c. conductivity of conducting PAni and its composite with temperature are shown in fig 5 .It is observed that 20wt% Composites shows good compare to other composites is the characteristic of "thermal activated behavior". The increase in conductivity could be due to increase of efficiency of charge transfer between the polymer chains and the dopant with increase in temperature . It is also possible that the thermal curing affects the chain alignment of polymer, which leads to the increase of conjugation length and that, brings about increase in conductivity. The conductivity varies directly with the temperature, obeying an expression of the following form:

$$(\sigma \ (T) = \sigma_0 \exp [-T_0/T)^{1/4}])$$

where: σ is the conductivity, T is the temperature and σ_0 is the conductivity at characteristic temperature T_0.

VI. AC CONDUCTIVITY

Figure 6 shows the ac conductivity of the Pani and Pani/ZnO nanocomposites as a function of the frequency at room temperature .It is found that there is increase in the conductivity of the nanocomposites for the increase in frequency and this pattern is same for all nanocomposites which obeys the universal power law but, at high frequency region, there is an sudden increase in the conductivity with increase in frequency which is the characteristic property of disordered materials. Among all composites, 20wt% shows highest conductivity and this may due to dipole polarization.

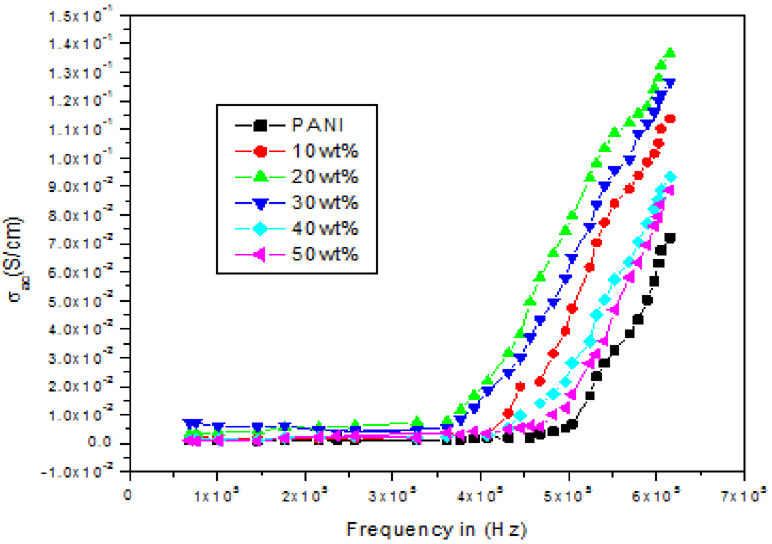


Figure 6 shows the variation of Ac conductivity Vs/Temperature

VII. CONCLUSIONS

Polyaniline composites were synthesized by in-situ polymerization method the electrical conductivity of Pani/ZnOnanocomposites were investigated . The electrical conductivity in these composites shows a strong dependence on content of ZnO particlesin Pani composites. Hence this nanocompositesare promising materials for potential applications.

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