Synthesis, Characterization and DC Conductivity of Cr_2O_3 doped Polyaniline Composites

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ABSTRACT:

The Polyaniline/ Cr_2O_3 composites were prepared at different weight percentage using ammonium persulphate as an oxidant. The prepared composites were characterized by XRD for structural studies and SEM to studies the morphology of the composites. The dc conductivity indicates there was a strong influence on the conductivity of small dopant added to the conducting polymer. It is observed that the value of dc conductivity of these composites increases exponentially with temperature. The conductivity behavior is the characteristic of amorphous materials.

Key words: Polyaniline; Chromium trioxide; Composites; scanning electron microscopy

INTRODUCTION:

Conducting polymers have been the subject of continuous research and development due to their potential applications in many technological areas. Conducting polymers offered the promise of achieving a new generation of polymers; materials which exhibit the electrical and optical properties of metals or semiconductors and which retain the attractive mechanical properties and processing advantages of polymer leading to wide range of technological applications [1-4]. Amongst the family of conducting polymers, polyaniline (PANI) is unique due to its ease of synthesis, environmental stability, and simple doping/dedoping chemistry. Because of its rich chemistry, polyaniline has been one of the most studied conducting polymers of the past 20 years. Polyaniline (PANI) is a promising material because of its intrinsic electrical conductivity by doping with organic dopants [5]. The highly order structures such as crystalline or self assembled structures of ideal conducting polymer with p-conjugated structure is expected to have metal-like electrical conductivity [6]. To induce an ordered structure, other materials acting as filler for the composite are required [7-14]. Nano structurization of conducting polymers and their composites emerged as a new field of research and development, directed to creation of new materials for use in modern and future technologies. Recently, conducting polymer/metal oxide nano particle composites have been

considered as a new class of materials due to their improved properties when compared with those of pure conducting polymer and metal oxide [15-17].

In this present paper the synthesis of polyaniline/ Cr_2O_3 composite. The prepared samples were characterized by XRD, SEM and DC conductivity studies shows that there are increases in conductivity with increase in temperature.

EXPERIMENTAL:

All Chemicals used were analytical reagent (AR) grade. The monomer aniline was doubly distilled prior to use. Ammonium persulphate ($(NH_4)_2S_2O_8$), Hydrochloric acid (HCl), chromium trioxide (Cr_2O_3), and titanium dioxide (TiO_2) were procured from Sigma Aldrich and were used as received.

SYNTHESIS

0.1 mol of aniline was dissolved in 1 M HCl to form aniline hydrochloride. Chromium trioxide (Cr_2O_3), is added in the weight percent of 10, 20, 30, 40 and 50 to aniline hydrochloride solution with vigorous stirring in order to keep the chromium trioxide, suspended in the solution. To this reaction mixture, 0.1 M of ammonium persulphate [$(NH_4)_2S_2O_8$] which acts as the oxidant was added slowly with continuous stirring for 4 – 6 hours at 0 – 5 ^{0} C. The precipitate powder recovered ware vacuum filtered and washed with water and acetone. Finally the resultant precipitate was dried in an oven for 24 hours to achieve a constant weight. In this way 5 different polyaniline Cr_2O_3 composites with different wt% of Cr_2O_3 (05, 10, 15, 20 and 25) in polyaniline have been synthesized. All the composites so obtained above are crushed into fine powder in an agate mortar in the presence of acetone medium.

CHARACTERIZATION:

The X-ray diffraction patterns of the samples in this present study are obtained on Philips X-ray diffractometer using CuK_α radiation (λ = 1.5406 Å). The diffractograms were recorded in terms of 2θ in the range $20^0 – 120^0$ with a scanning rate of 2^0 per minute.

RESULTS AND DISCUSSION:

Figure-1 shows XRD patterns for PANI/Cr_2O_3 composite with 25 wt% of Cr_2O_3 in PANI. It is seen from figure 1, that the rhombohedra peak of Cr_2O_3 indicates the crystalline nature of the composite. By comparing the XRD pattern of the composite with that of Cr_2O_3, the prominent peaks corresponding to 2q = 25.1, 34.22, 36.83, 50.85 and 55.49 are due to (0 1 2), (1 0 4), (1 1 0), (0 2 4) and (1 1 6) planes of Cr_2O_3 [JCPDS file no. 38 -1479]. By comparing the XRD pattern of the composite and Cr_2O_3, it is confirmed that Cr_2O_3 has retained its structure even though it is dispersed in PANI during polymerization reaction [10].

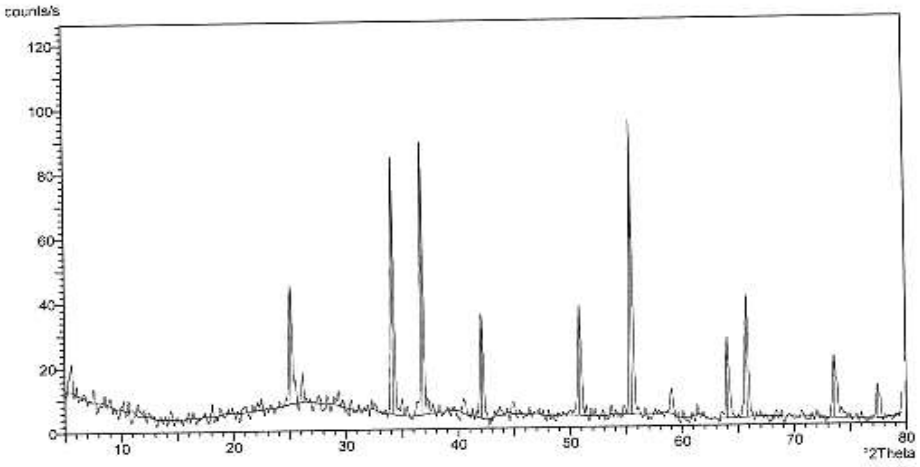

Figure-1: X-ray diffraction pattern of Polyaniline – Cr_2O_3 composites

Figure-2(a) shows the scanning electron micrograph of Cr_2O_3 and it is found that the SEM image of Cr_2O_3 is like clustered granules.

Figure-2(b) shows the scanning electron micrograph of Polyaniline / Cr_2O_3 composite (25 wt% of Cr_2O_3 in Polyaniline). Among five composites that were synthesized using Cr_2O_3 with different wt% (05, 10, 15, 20 and 25), a composite of Polyaniline / Cr_2O_3 with 25 wt% of Cr_2O_3 in Polyaniline is selected to obtain the SEM micrograph as it gives the better dispersion of Cr_2O_3 molecules in PANI. Cr_2O_3 molecules are embedded in polymer matrix.

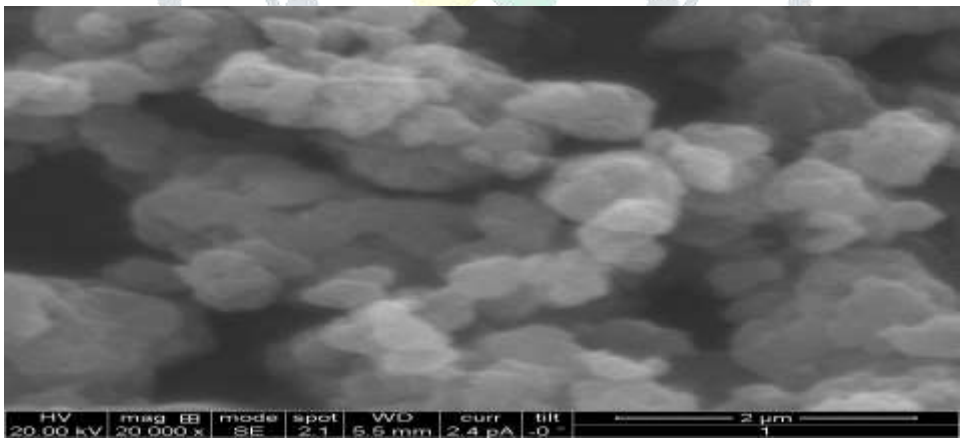

Figure-2(a): SEM Micrograph of Cr_2O_3 composite

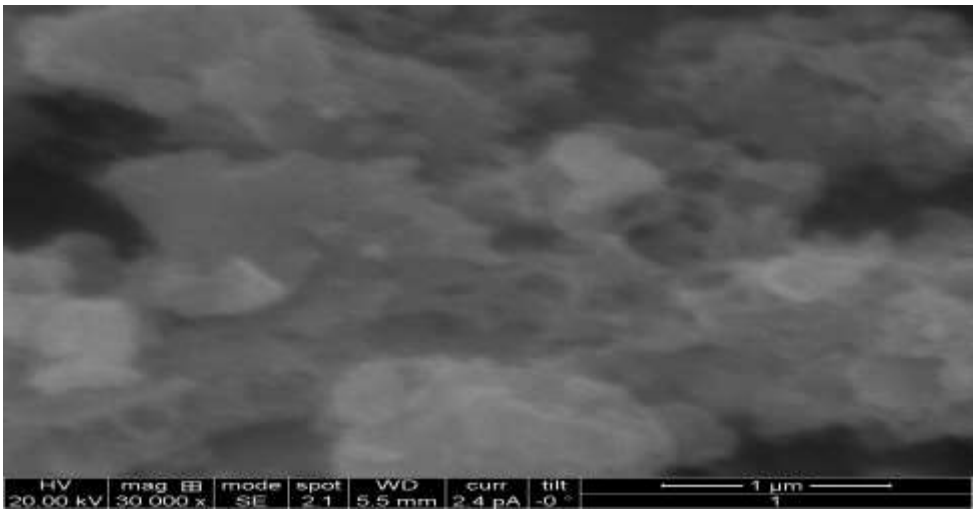

Figure-2(b): SEM Micrograph of Polyaniline – Cr_2O_3 composite

A high magnification reveals the presence of Cr_2O_3 in Polyaniline which is homogeneously distributed throughout the polymer sample. From SEM micrograph it clearly indicates that it has highly clustered structure. The presence of Cr_2O_3 has a strong influence on various electrical parameters such as conductivity and dielectric behavior of these composites. The contrast in the image is due to the difference in scattering from different surface areas as a result of geometrical differences between Polyaniline and Cr_2O_3.

DC CONDUCTIVITY:

Figure-3 shows the variation of dc conductivity as a function of temperature for Cr_2O_3 in Polyaniline. It is observed that the value of dc conductivity of these composites increases exponentially with temperature. It remains nearly constant up to 100^0C and there after it increases exponentially. The conductivity behavior is the characteristic of amorphous materials. It is found to increase in conductivity with wt% and is due to extended chain length of Polyaniline in which the charge carriers possess sufficient energy to hop between various favorable localized sites.

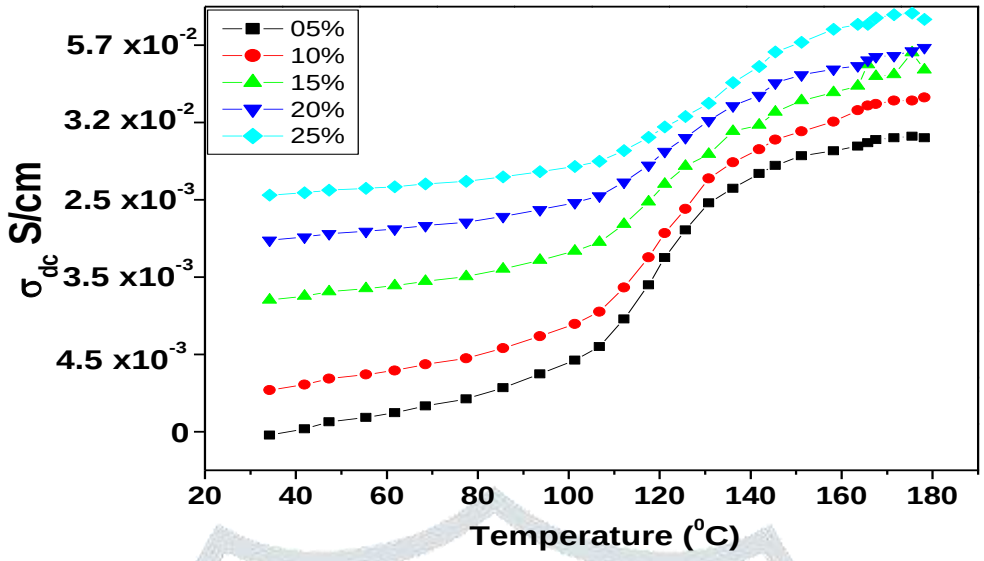

Figure-3: The dc conductivity of Polyaniline/Cr_2O_3 composites

CONCLUSION:

Polyaniline Cr_2O_3 composites were prepared by in-situ polymerization method. The SEM and XRD study performed on these samples indicates clearly that it has highly clustered structure and the homogeneous distribution of Cr_2O_3 particle in PANI composites. The presence of Cr_2O_3 particle in PANI composites influences electrical parameter such as conductivity of these composites. The DC conductivity studies shows that the strong influence exhibits the typical semiconductor behavior. Hence PANI/Cr_2O_3 composite is one of the materials for the potential applications.

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