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Correlation of surface morphology and Conductivity of Polyaniline / Cr_2O_3 Composites

KEYWORDS: conductivity; polyaniline composites; Cr_2O_3; SEM

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ABSTRACT *The PANI/Cr_2O_3 composites have been synthesized with various compositions viz., 05, 10, 15, 20 and 25 wt % of Cr_2O_3 in PANI. The surface morphology is influence the conductivity of the composites. It is observed that 25 wt% of PANI-Cr_2O_3 composites morphology is more suitable for transport mechanism. Among all composites 25 wt% shows high conductivity.*

2. Introduction

Polymer-based electronics is a progressively increasing area of research due to expectations of production of electronic circuits and devices with cheap and simple technologies on almost any type (even flexible) of support. Conducting polymers has received a great deal of attention in the last two decades. Among the list of conducting polymers, polyaniline (PANi) has been of particular interest because of its cheap monomer, simple synthesis technology, unique electrochemical properties, high conductivity and environmental stability [1].

After the discovery of the first conducting polymer in 1976, many applications of metal based semiconductors are replaced by conducting polymers. Perhaps more surprisingly these materials showed promise in many biomedical applications also. Conductive polymers can be utilized as unique functional elements in future intelligent biomaterials required for tissue engineering, cell stimulation and drug delivery. Polymers being the organic materials are more likely to be biocompatible than its metallic counterpart. Therefore the synthesis of magnetic polymer gives the pathway for the above applications. Realizing magnetism in polymeric material helps us to make use of such polymer for selective delivery of drugs, targeting the cancer tissue into the human body, etc [2].

In this present work, Cr_2O_3, a transition metal oxide is mixed with PANi at different doping levels (5, 10, 15, 20 and 25 wt %). The correlations of morphology with DC conductivity behavior of PANi-Cr_2O_3 composites were discussed.

3. Experimental

Aniline (AR grade) was purified by distillation before use and ammonium per sulphate [$(NH4)_2S_2O_8$)], HCl were used as received. 0.1 mole aniline monomer is dissolved in 1 mole hydrochloric acid to form polyaniline. Fine graded pre-sintered chromium oxide (AR grade, SD-Fine Chem.) powder in the weight percentages (wt %) of 5, 10, 15, 20 and 25 is added to the polymerization mixture with vigorous stirring in order to keep the chromium oxide powder suspended in the solution. To this reaction mixture, [$(NH4)_2S_2O_8$)] which is used as an oxidant is added slowly drop-wise with continuous vigorous stirring for the period of 4-6 hours at temperature 0-5 ^{0}C. Polymerization of aniline takes place over fine grade chromium oxide particles. The resulting precipitate is filtered under suction and washed with distilled water until the filtrate becomes colorless. Acetone is used to dissolve any unreacted aniline. After washing, the precipitate is dried under dynamic vacuum at 60-800C for 24 hrs to get resulting composites. In this way, five different polyaniline chromium oxide composites with different weight percentage of chromium oxide (5, 10, 15, 20 and 25) in polyaniline have been synthesized. All the composites are crushed into fine powder in an agate mortar in the presence of acetone medium. The composite powder so obtained is pressed to form pellets of 10mm diameter and thickness which varies from 2 to 2.75 mm [3].

4. Characterization

The samples were sputtered with gold and then the surface morphology of the composites was investigated by scanning electron microscope (SEM, JEOL/EO JSM-6360). DC conductivity of polyaniline – Cr_2O_3 composites was measured by using two proves method.

5. Results and discussion

5.1. Scanning electron microscopic

The SEM micrograph of conducting polyaniline synthesized by chemical oxidative method is shown in figure 1(a). It can be clearly seen that the micrograph of polyaniline is branched and homogeneous. Since Hydrochloric acid is used as protonic acid in the preparation of polyaniline, the presence of microcrystalline structure can be seen.

The presence of microcrystalline structures in polyaniline in this particular sample can be confirmed from XRD studies. Since conducting polymers are very sensitive to the temperature, due to the interaction between electron and the sample, considerable amount of heat is generated which causes the development of mall crackening in the sample during SEM recording.

A granular morphology of the microcrystalline structures is measured and is found to be about 312 nm in diameter for polyaniline which is consistent with other reports [4]. The contrast in the image is a result of differences in scattering from different areas of the surface as a result of geometrical differences.

Figure 1 (b) shows the scanning electron micrograph of polyaniline / Cr_2O_3 composite (25 wt% of Cr_2O_3 in polyaniline). Cr_2O_3 molecules are embedded in polymer matrix homogeneously. The size of the granular is around 344.2 nm. 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.

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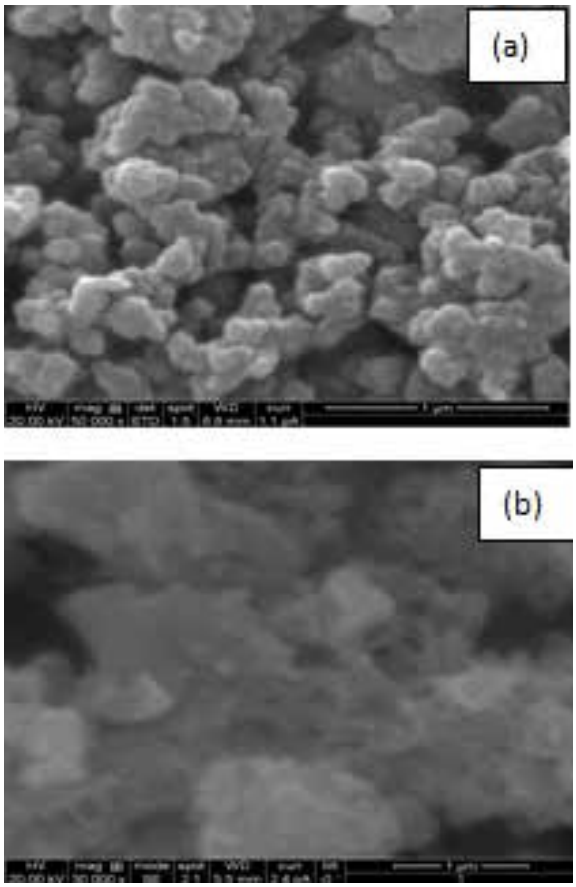

Figure 1 (a, b) shows the pure polyaniline and polyaniline-Cr_2O_3 composites of 25 wt%

5.2. DC Conductivity

Figure 2 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°C and there after it increases exponentially. The conductivity behaviour is the characteristic of amorphous materials. The initial decrease in the conductivity values up to 20wt% of Cr_2O_3 in polyaniline may be due to blocking of charge carrier. However, it is found to increase for 25 wt% and is due to extended chain length of polyaniline in which the charge carriers possess sufficient energy to hopp between various favorable localized sites.

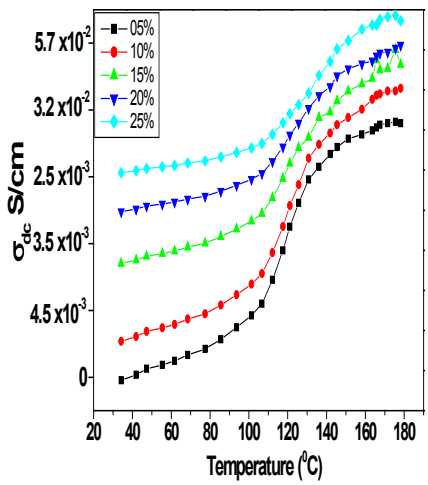

Figure 2 shows the dc conductivity of polyaniline – Cr_2O_3 composites

6. Conclusion

Polyaniline-Cr_2O_3 composites have been prepared by institute polymerization technique. The prepared composites are characterized by SEM. The DC conductivity increases with increase in dopant weight percentage and it is confirmed the increase in conductivity due to hopping of polorans explained by Mott theory.

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