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Synthesis, Characterization and DC Conductivity Study of Polyaniline / Pr_2O_3 Composites

KEYWORDS: Polyaniline, composite, Pr2O3, ac conductivity

Sangshetty Kalyane

Department of Physics, BKIT, Bhalki, Karnataka, India-585328

ABSTRACT *Composites of Polyaniline dispersed with Pr2O3 materials were prepared by insitu polymerization of aniline using ammonium persulphate as an oxidizing agent. Different weight percentage of Pr2O3 is dispersed for polyaniline composites. Polyaniline and its composites were characterized by X-ray diffraction (XRD), Scanning electron Micrograph (SEM), and Fourier transform infrared techniques (FTIR). These studies showed the dispersion of oxide particles in the polyaniline matrix.DC Conductivity study shows that the decrease and increase in conductivity due to the amount of dispersed Pr2O3 in polyaniline matrix observed.*

1. Introduction

Polymer composites represent a new class of conventionally filled polymer materials which increases strength, heat resistance and decreased flammability[1] These Polymer Composites materials are formed by dispersion of inorganic particles in an organic polymer matrix to dramatically improve the performance properties of the polymer [2-3]. Metal oxides dispersed polymer composites have attracted a great deal of interest from researchers, because they frequently exhibit unexpected hybrid properties synergistically derived from both components [4-5]. Similarly, conducting polymer composites have attracted considerable interest in recent years because of their numerous applications in variety of electrical and electronic devices. Composites of conducting polymer with suitable compositions with inorganic materials led to desirable properties [6-7]. Conducting polymer composites materials are especially important owing to their bridging role between the world of conducting polymers and that of nano materials. For application of conducting polymers knowing how these conducting polymers composite will affect the behavior in an electric field is a long-standing problem and great importance. The discovery of doping in conducting polymer has led to further dramatic increase in the conductivity of such conjugated polymers.

Combining conducting polymers with metal oxide particles, one could produce polymer composites, the properties of which can be tuned depending upon the composition of metal oxide in the polymer matrix [8]. Polyaniline composites have been widely studied in view of their unique electrical , optical and optoelectrical properties in addition to their ease of preparation and excellent environmental stability.

Conducting Polyaniline and its composites with metal oxides has recently been the subject for the researchers with great interest [9]. The insulating emeraldine base form of PANI consists of equal number of reduced and oxidized repeat units. The conducting emeraldine salt form is achieved by doping with aqueous protonic acids. This leads to an increase in conductivity by more than 10 orders of magnitude depending on the strength of the acids [10-11].

Present investigation reports a simple, yet elegant method to prepare polymer composites using PANI. In this method, PANI was dispersed with 10, 20, 30, 40 and 50 mass % Pr2O3 material during in situ polymerization of aniline in the presence of ammonium persulphate as an oxidant. Thus as prepared polyaniline and its metal oxide composites were characterized by X-ray diffraction (XRD), Fourier transform infrared (FTIR), Scanning electron microscopy (SEM), and Conductivity for the sample were also studied.

2. Experimental

2.1. Materials and Methods

Ammonium persulphate (NH4)2S2O8, Hydrochloric acid (HCl) and Praseodymium oxide(Pr2O3) used were of AR grade. Doubly distilled water and aniline is used as a solvent and monomer. Polyaniline is prepared by oxidation aniline and Polyaniline composites were prepared by insitu polymerization method with dispersion of Pr2O3

2.2. Synthesis of Polyaniline/Pr2O3 Composites

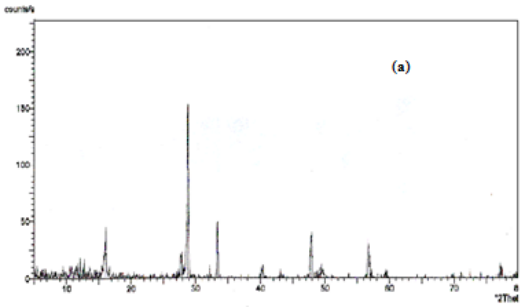
Aniline was dissolved in 1m HCl to form polyaniline (PANI). Praseodymium oxide was added to PANI solution with vigorous stirring to keep the praseodymium oxide suspended in the solution. To this reaction mixture, 0.1M of ammonium persulphate [(NH4)2S2O8], which acts as the oxidant, was added slowly with continuous stirring for 4-6 hours at 0-5Oc. The precipitated powder recover was vacuum-filtered and washed with deionizer water. Finally, the resultant precipitate was dried in an oven for 24 hours to achieve a constant weight. In the similar manner plain PANI is prepared without adding praseodymium oxide.

PANI/Pr2O3 composites were prepared in weight percent ratio in which the concentration of Praseodymium oxide (10, 20, 30, 40 and 50%) was varied. The test samples to be used were prepared in pellet form of diameter 10mm and thickness 3mm by applying pressure of 7t using Pye-Unicam dye. The contacts for these composites were made using silver paste as electrodes on both sides.

3. Results and Discussions

3.1. X-ray diffraction

Figure 1 (a) & (b) shows the X-ray diffraction pattern of (a) Pr2O3 (b) Polyaniline - Pr2O3 composite (50 wt % of Pr2O3 in PANI). It is seen from the figure 1 (a) & (b) that the cubic peaks of Praseodymium oxide indicates the crystalline nature of the composite. By comparing the XRD pattern of composite with that of Pr2O3 (JCPDS No. 47-1111) the prominent peaks corresponding to 2 θ = 26.75 0 56.09 are due to (100), and (100) planes of Pr2O3. By comparing the XRD patterns of the composite and Pr2O3, it is confirmed that Pr2O3 has retained its structure even though it is dispersed in PANI during polymerization reaction.



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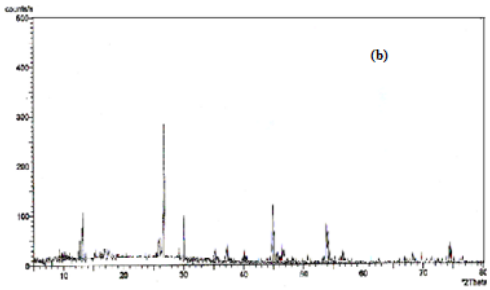

Figure 1: X – Ray diffraction pattern of (a) Pr2O3 (b) Polyaniline / Pr2O3 composite (50 wt %)

3.2. Infrared Study

Figure 2(a) shows the IR spectra of pure Pr2O3. The important peaks are observed at 863 and 665 cm-1. The 665 cm-1 peak confirms the presence of Pr2O3. The IR spectra of polyaniline – Pr2O3 composite (50 wt % of Pr2O3 in PANI) is shown in figure 2 (b). The prominent peaks that are observed in polyaniline – Pr2O3 composite are 1572 cm-1, 1486 cm-1, 1307 cm-1, 1251 cm-1, 1146 cm-1,880 cm-1 ,819cm-1 707cm-1, 596 cm-1 and 504 cm-1. By careful observation of IR the characteristic stretching frequencies are considerably shifted towards higher frequency side. The data suggest that, there is a Vander walls kind of kind of interaction between the polymeric chain and Pr2O3.

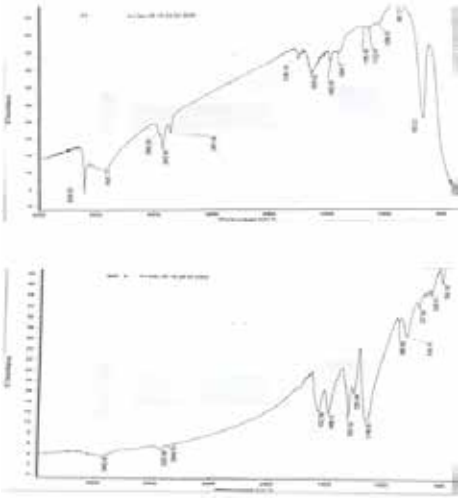

Figure 2: FTIR spectra of (a) Pr2O3 & (b) PANI /Pr2O3 composite (50 wt%)

2.3. Scanning Electron Micrograph Study

The SEM micrograph of polyaniline – Pr2O3 composite with 50 wt % of Pr2O3 in polyaniline is shown in figure 3.The composites possess grains and porous structure. Further the composites have capillary pores connected by pores. Such composites are likely to facilitate the absorption of water vapors due to the large surface area and capillary pores [12]. The presence of such sharp crystals of Pr2O3 has a strong influence on various electrical properties such as conductivity and dielectric behavior of these composites.

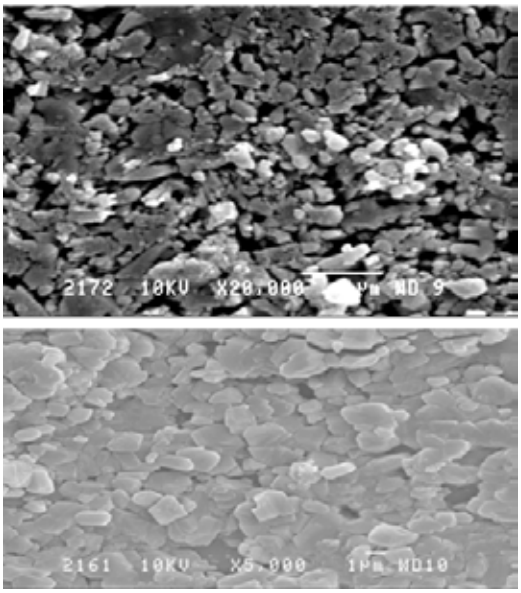

Figure 3: SEM Micrograph of (a) Pr2O3 (b) Polyaniline - Pr2O3 (50 wt %)

2.4. d.c Conductivity study

Figure 4 shows the variation of dc conductivity as a function of wt % Pr2O3 in polyaniline at two fixed temperatures viz., at 1000 and 2000 C. It is observed that the conductivity values increase up to 40 wt % of Pr2O3 in polyaniline and then decreases. This is attributed due to extended chain length of polyaniline which facilitate the hopping of charge carriers when the content of Pr2O3 is up to 40 wt %. Further the decrease in conductivity is observed which may be attributed due to the distribution of Pr2O3 particles of larger grain size which are partially blocking the hopping of charge carriers [13].

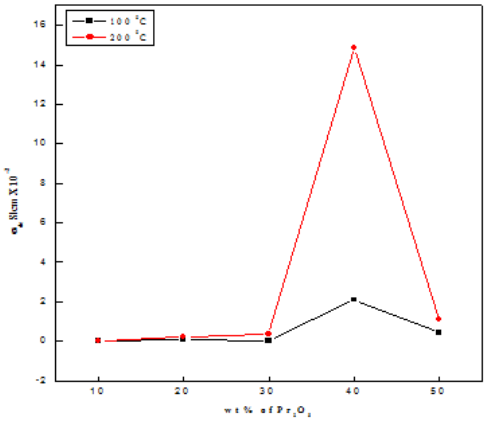

Figure 4: Variation of θ dc as a function of weight % of Pr2O3 in PANI at different temperature

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