



AC CONDUCTIVITY OF POLYANILINE – NICKEL OXIDE COMPOSITE

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Abstract: *Polyaniline –NiO composite have been prepared by using ammonium persulphate. The prepared composites were characterized for structural and morphology studies by FTIR and SEM. Further the ac conductivity was carried by two probe method. It is found that the conductivity increases with increase in frequency. Among, all composites 25 wt% shows high conductivity due to space charge polarization.*

Keywords: *Composite, Ac conductivity, FTIR, Scanning electron microscopy*

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INTRODUCTION

As a typical highly conjugated conductive polymer, polyaniline (PANI) has the unique properties of ease of preparation, high environmental stability, and a special doping mechanism [1] and has potential applications in polymeric conducting molecular chemical sensors, supporting material for catalysts, light-emitting and electronic devices, and so forth [2]. Recently, the morphology of PANI has aroused considerable interest and has been widely studied for its influence on physical properties. Zeolite, porous alumina, and polymer fibers have been used as hard templates to synthesize PANI nanotubes and nanofibers. Organized molecular assemblies of micelles, inverse micelles, and lamellar liquid crystals have been applied as soft templates to obtain various morphologies of PANI, such as nanotubes, nanorods, nanofibers, and hollow microspheres. Wan and Li also proposed a template-free method for fabricating microtubes of PANI in the presence of b-naphthalene sulfonic acid as a dopant. The preparation of PANI composites with inorganic particles has also aroused great interest because of their multifunctionality. PANI/TiO₂ and PANI/Fe₃O₄ composite nanotubes [3] have been reported by a self assembly process.

Nickel oxide is one of the important materials in the application of electrochemical capacitor, battery electrode, catalysis and in electromagnetic device. This metal oxide could be prepared by different methods like sol-gel, combustion, SPCR, Hydrothermal and solvothermal technique etc. Here we have report, synthesis, characterization and conductivity of polyaniline –NiO composites at various weight percentages.

EXPERIMENTS

Materials and method

All Chemicals used were analytical grade (AR). The monomer aniline was doubly distilled prior to use. Ammonium persulphate ((NH₄)₂S₂O₈), Nickel oxide (NiO), hydrochloric acid (HCl) were procured and were used as received.

Preparation of polyaniline

Ammonium persulphate (0.1 mole aqueous solutions in protonic acid) is added drop wise to a stirred solution of 0.1 mole aniline dissolved in 1 mole of aqueous solution of hydrochloric acid, pre cooled to 3 – 5 ° C. Ammonium persulphate solution is added very slowly to prevent the warming of the solution. After completion of the addition, stirring is continued for 2 hours by using a mechanical stirred to ensure the completion of reaction. The time



of initial coloration on mixing of reactants depends upon the temperature and protonic acid. During the polymerization reaction, HCl is used as a protonic acid and a temperature of $0 - 5^{\circ}\text{C}$ is maintained by using a freezing mixture. The end product of green color precipitate is obtained. The precipitate was filtered, washed with deionised water and finally dried in an oven for 24 hrs to achieve a constant weight

Synthesis of Polyaniline / NiO Composites

0.1 mol of aniline was dissolved in 1 M HCl to form aniline hydrochloride. Nickel oxide (NiO), 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 NiO, suspended in the solution. To this reaction mixture, 0.1 M of ammonium persulphate $[(\text{NH}_4)_2\text{S}_2\text{O}_8]$ which acts as the oxidant was added slowly with continuous stirring for 4 – 6 hours at $0 - 5^{\circ}\text{C}$. The precipitate powder recovered were 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 NiO composites with different wt% of NiO (05, 10, 15, 20 and 25) in polyaniline have been synthesized.

The IR spectra of all the samples are recorded on Perkin Elmer (model 783) IR spectrometer in KBr medium at room temperature. For recording IR spectra, powders are mixed with KBr in the ratio 1:25 by weight to ensure uniform dispersion. The mixed powders are pressed in a cylindrical die to obtain clean discs of approximately 1 mm thickness. 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 was carried out by using Kelvin two probes and the resistance was measured using Keithley meter.

Results and Discussion

Figure 2 shows the IR spectra of PANI/ NiO composite (25 % wt of NiO in PANI). The IR transmission spectra of powder using KBr pellets having different weight percentage of NiO in PANI were recorded in the range $450 - 4000\text{ cm}^{-1}$ to confirm polymerization of polyaniline. The spectra for all the samples showed strong bands in the region $500 - 1600\text{ cm}^{-1}$ that are the characteristics of PANI.

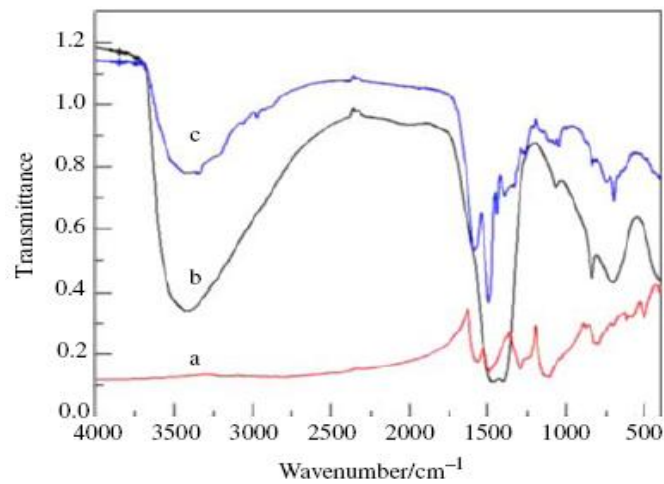


Figure 1 FTIR spectra of (a) Polyaniline, (b) NiO and (c) Polyaniline – NiO composite (25 wt %) Similar stretching frequencies can also be found in other composites but intensity of metal oxygen peak increases as the weight present of NiO is increased [4]. The important peaks that are observed in this composite in IR spectra are observed at 1648 cm^{-1} , 1564 cm^{-1} , 1488 cm^{-1} , 1394 cm^{-1} , 1303 cm^{-1} , 1252 cm^{-1} , 1118 cm^{-1} , 882 cm^{-1} , 804 cm^{-1} , 595 cm^{-1} and 512 cm^{-1} . It is found from the FTIR spectra that some of the characteristic stretching frequencies are considerably shifted towards higher frequency side. The typical peaks observed are at 1564 cm^{-1} , 1488 cm^{-1} , 1303 cm^{-1} , 801 cm^{-1} and 512 cm^{-1} , which may be attributed due to the weak interaction between NiO and PANI chain.

The SEM image of pure NiO is shown in figure 2 (a) and it is observed to have the rectangular like shape. The average length is found to be of 392.1 nm. These structures play an important role in enhancing the electrical property of the composites. The SEM micrograph of polyaniline / NiO composite with 25 wt% of NiO in polyaniline is shown in figure 2 (b). High magnification SEM image reveals the presence of NiO particles uniformly distributed throughout the composite sample.

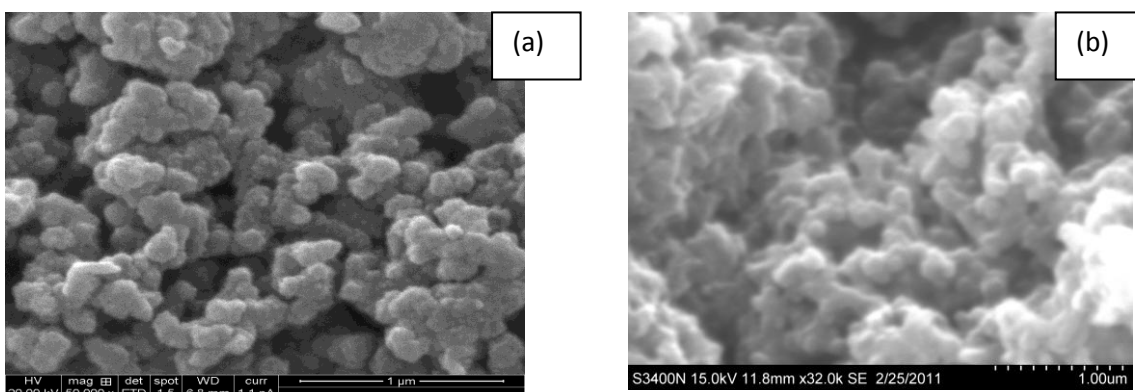


Figure 2 (a, b) SEM Micrograph of polyaniline and polyaniline – NiO composite



A small variation in the particle dimensions of NiO so dispersed in polyaniline has been observed. Also fibrillar morphology is observed in the composite. The size of these crystallite is around 356.5 nm. 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 NiO. Since structure property correlation plays a significant role, a correlation between dimension of NiO used for composite preparation and its effect on electrical properties.

AC Conductivity

Figure 3 shows the variation of ac conductivity as a function of frequency for polyaniline – NiO composites (different wt %). It is observed that in all the cases, σ_{ac} remains constant up to 10^5 Hz. The maximum value of conductivity is observed for 25 wt% at 10^5 Hz. This behaviour is attributed to addition of NiO in polymer matrix. It is observed that in all the composites the conductivity increases at 05 & 20 wt of NiO in polyaniline. This may be due to the extended chain length of polyaniline which facilitate the polarization of charge carriers.

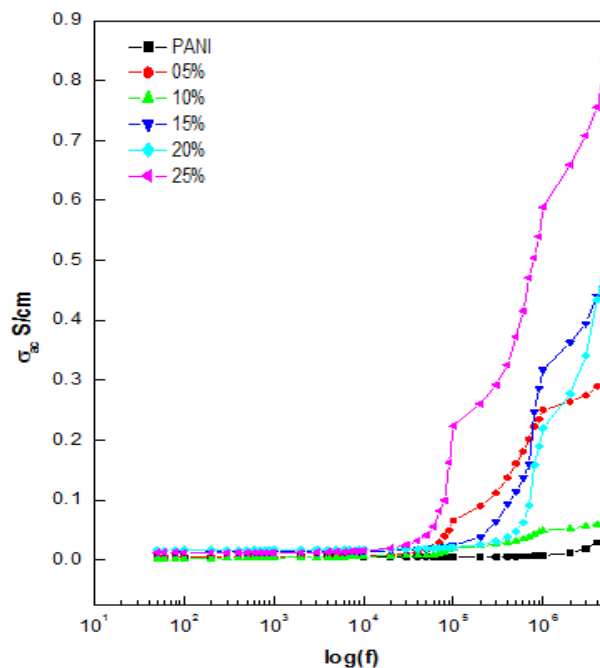


Figure 3 shows the ac conductivity of polyaniline – NiO composites

CONCLUSION

Nickel oxide doped polyaniline composites have been prepared by in situ polymerization. The prepared composite was characterized for structural studies by FTIR, indicates the 1564 cm^{-1} , 1488 cm^{-1} , 1303 cm^{-1} , 801 cm^{-1} and 512 cm^{-1} , which may be attributed due to the weak



interaction between NiO and PANI chain. SEM image reveals that the particles size decreases with increase in NiO weight percentage. The ac conductivity increases with increase in frequency. Among, all composites 25 wt% shows high conductivity due to space charge polarization.

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