



Synthesis and Structural Characterization of Nickel Oxide-Polyaniline Nanocomposite

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ABSTRACT

Nickel oxide polyaniline nanocomposite (NiO-PANI) was synthesized by in situ polymerization technique in sulphuric acid medium with ammonium persulphate as an oxidizing agent in the presence of synthesized nanoparticles NiO as reinforcing filler so as to study the effect of filler nanoparticles on the properties of the conducting polyaniline. The synthesized nanocomposite was characterized by Transmission Electron Microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), Ultraviolet visible spectroscopy (UV). TEM pattern shows uniform NiO-PANI nanoparticles having diameter 20nm. FTIR spectroscopy shows that NiO nanoparticles get electrostatically bound to the specific sites of polyaniline. UV- visible spectroscopy shows that coating of NiO nanoparticles on PANI backbone.

Keywords: Conducting Polymer, Polyaniline, Nano Nickel Oxide, Nanocomposite, TEM, FTIR.

I. INTRODUCTION

Polymer nanocomposites containing inorganic particles have attracted great attention as they can combine the advantages of both polymer and inorganic nanoparticles. The conducting polymers have emerged as a new class of materials because of their mechanical strength, electrical conductivity and stability. By proper doping the conductivity of these materials can be varied from semiconducting to metallic regime, which has offered new concept of charge transport mechanism. Hence PANI is useful in wide area of application such as solar energy conversion, rechargeable batteries, electrochromic displays, electrochemical sensors, capacitors and active corrosion protector. Due to ease of synthesis, processing environmental stability and low synthetic cost, polyaniline is probably the most important industrial conducting polymer today. Preparation of composites of conducting polymer (PANI) has been considered to provide a suitable solution to the processibility problem [1-3]. These nanocomposites have the ability to enhance their material properties with desirable mechanical and physical characteristics.

Therefore, there has been increasing interest of the researchers for the preparation of nanocomposites based on PANI.

The preparation of PANI composites with nano nickel oxide particles has also created great interest because of their multifunctionality. To obtain materials with synergetic advantage between PANI and inorganic nanoparticles, various composites of PANI with inorganic nanoparticles such as Fe₃O₄, NiO [4-7], BaTiO₃, ZnO [8] PANI-CNT [9-11] are reported. We present here the preparation of NiO nanoparticles by chemical precipitation method and used it for the preparation of nanocomposites. In this paper we report the synthesis and effect of nickel oxide as nanosized filler on the structural characterization of the conducting polyaniline nanocomposite.

II. METHODS AND MATERIAL

All chemicals used in this experiment were of reagent grade and used without any further purification. Nickel carbonate hexahydrate (NiCO₃.6H₂O) was purchased

from Merck, sodium hydroxide (NaOH) was purchased from Sigma-Aldrich. Ethyl alcohol and acetone were received from Merck. All solutions were prepared with deionized water.

Transmission electron microscopy image was obtained using Jeol/JEM-2100 TEM with resolution 2.3Å. FTIR spectra were performed on Thermo Nicolet, FTIR-370A Spectrophotometer in the wavelength range of 400–4000 cm^{-1} . The optical absorption spectra was carried out using UV-5000 double beam spectrophotometer.

A. Synthesis of NiO nanoparticles and PANI/NiO nanocomposites

Among various soft chemical methods for preparing nanooxide materials, chemical precipitation method is widely used due to the process simplicity. This technique offers several unique advantages over other methods including easy work-up, low temperature processing, short reaction time, and production of inorganic nanomaterials with narrow size distribution. Nickel oxide (NiO) nanoparticles were prepared by the simple approach of chemical precipitation method in which, 1gm starch solution prepared in 100ml distilled water was added in 0.1M nickel carbonate hexahydrate ($\text{NiCO}_3 \cdot 6\text{H}_2\text{O}$) solution and the mixture was stirred at room temperature for 1 h. Then 1M sodium hydroxide (NaOH) was added drop wise in the solution under constant stirring for 2h. After complete addition of sodium hydroxide, the solution with light green ppt was filtered using membrane filtration assembly and washed with deionized water and ethanol to remove the impurities and then dried at 70°C in hot air oven [12]. Dried sample was treated at different temperatures in order to maintain the stability of compound. The color of the sample was changed from green to faint gray at 100°C to 700°C.

This nickel oxide is used to prepare NiO-PANI nanocomposites. The synthesized NiO nanoparticles were incorporated in PANI matrix by an in-situ chemical oxidative polymerization [13].

III. RESULTS AND DISCUSSION

A. TEM analysis

“Figure 1A, 1B” shows TEM images of NiO, NiO-PANI nanocomposite. TEM image (A) indicated that compact arrangement of NiO nanoparticles have rough spherical

morphology and average particle size of 20nm[14]. TEM image (B) of PANI/NiO nanocomposite elucidated that presence of sharp crystalline NiO nanoparticles exist in the PANI matrix of morphological tubular structure indicating strong influence of NiO nanoparticles on PANI.

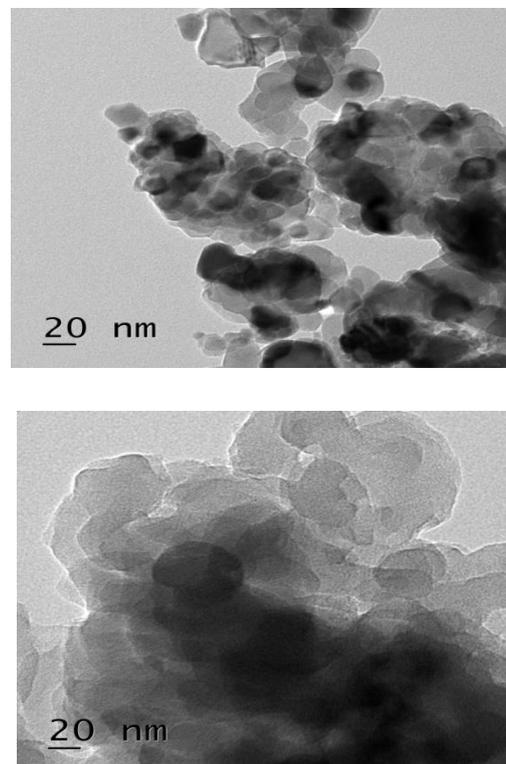


Figure 1. TEM pattern of A : NiO
B: NiO-PANI nanocomposite

B. FTIR analysis

“Figure 2A and 2B” shows the FTIR spectra of NiO and NiO-PANI nanocomposite. FT-IR spectra of NiO nanoparticles shows strong band at 425 cm^{-1} corresponds to the vibration of Ni–O bond [15]. It could be seen from Fig. 2A that the broad absorption band centered at 3394 cm^{-1} is attributable to the band O–H stretching vibrations, due to the fact that the calcined powders tend to physically absorb water[16].

FT-IR spectra of NiO-PANI shows bands at 694 cm^{-1} , 825 cm^{-1} , 1,501 cm^{-1} , 3,235 cm^{-1} are assigned to Ni–O interaction with PANI. A weak asymmetric band at 1147 cm^{-1} support the presence of OH^- group due to the absorption of water by nanoparticles during preparation of nanocomposite[17].

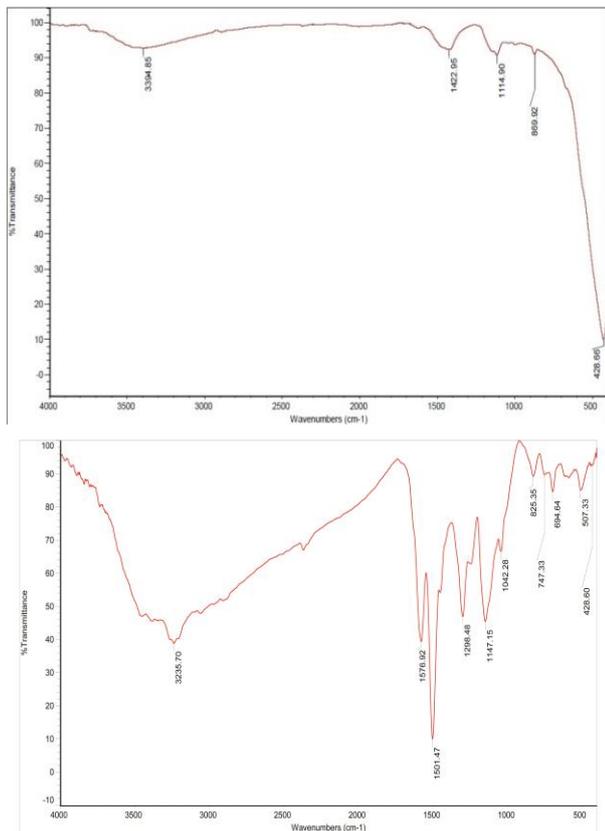


Figure 2. FTIR spectra of **A : NiO**
B : NiO-PANI nanocomposite

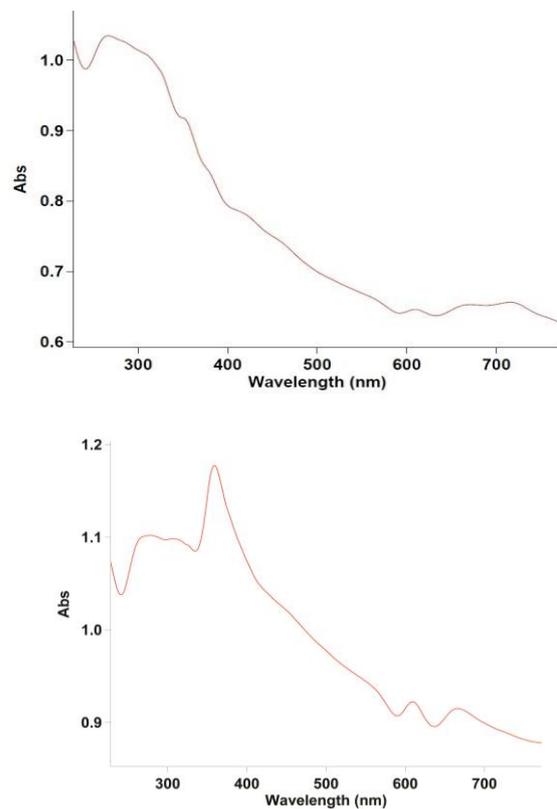


Figure 3. UV Visible spectra of **A :NiO**
B : NiO-PANI nanocomposite

C. UV-VIS analysis

UV-visible spectra of NiO and NiO-PANI-nanocomposite in DMF solvent are shown in Fig. 3A and 3B. UV-visible spectra of NiO shows strong absorption band at 266 nm attributed to the electronic transition from the valence band to the conduction band in the NiO semiconductor [18-19].

UV-visible Spectra of NiO-PANI nanocomposite also shows two characteristics peaks at wavelength of 359nm and 666nm. The first peak corresponds to the formation of nickel oxide while the latter on peaks at 666nm corresponds to the formation of Polyaniline. It can be seen from the figure that absorbance occurs at 666nm due to the transition of two benzenoid rings to the Quinoid rings of the PANI chain. The sample exhibit maximum absorption at 359nm shows the π -conjugated system transition of oxide nanoparticles[20].

IV. CONCLUSION

NiO-PANI nanocomposite have been successfully synthesized by an in-situ chemical oxidative polymerization method. The incorporation of oxide nanoparticles into PANI affects on structural characterization of NiO-PANI nanocomposite . TEM images, FTIR spectra and UV-Visible spectra of NiO-PANI nanocomposite indicate confirmation of NiO-PANI nanocomposite. Such nanocomposite forming conductive magnetic materials may be useful for potential and sensing applications.

V. REFERENCES

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