

Synthesis and Characterization of Polyaniline-co-Polythiophene-NiO hybrid Nanocomposite for electrical application

¹J.Vidya, ²P.Balamurugan

¹Research Scholar, ²Assistant Professor

^{1,2}PG and Research Department of Physics, Government Arts College for Men (A), Nandanam, Chennai –35

Abstract: The polyaniline-co-polythiophene-Ni hybrid nanocomposite was prepared by in situ chemical polymerization. The morphology and chemical structure of the nanomaterial was characterized by Field emission scanning electron microscopy, X-ray Diffraction and Fourier transform infrared spectroscopy. Optical properties of the nanocomposite was analysed by UV-Visible and photoluminescence spectroscopy. I-V characteristics of the nanomaterial showed that the ohmic (linear) behaviour between current and voltage. The zeta potential of Polyaniline -co-Polythiophene -Ni was -46mv and it showed that the as prepared nanocomposite has good chemical stability.

Keywords: Polyaniline, Polythiophene, Nickel sulphate and nanocomposites.

I. INTRODUCTION

In present days, designing of multifunctional core-shell nanocomposites comprising organic and inorganic constituents represent a novel class of materials [1-3]. The newly formed nanocomposite material possesses superior properties than the individual constituent materials. Depending upon the composition of the core and shell materials, these particles create a class of materials with unique chemical as well as physical properties and they find applications in a wide range of fields. Among the conjugated conducting polymers, polyaniline and polythiophene have attracted much interest worldwide because of their high environmental, thermal and chemical stability and their high conductivities. These polymers have conjugated structure with alternating single and double bonds or conjugated segments coupled with atoms providing *p*-orbitals for a continuous orbital overlap for polymers to become intrinsically conducting and to be electronically conductive they must possess not only charge carriers but also an orbital system that allows the charge carriers to move. Conducting polymers may therefore find applications in electromagnetic interference (EMI) shielding, transparent packaging of electronic components, solar cells, nonlinear optical display devices, conducting and semiconducting electrical circuits and supercapacitors [4-12]. S.R.Takpire et al [13] reported polythiophene-co-polyaniline-Ti composites for PV system. In this work, nickel sulphate added PANi-co PTh nanocomposite was prepared by chemical polymerization method and its morphological and electrical and electrochemical properties were discussed.

2. Materials used and Experimental method

Nickel sulphate, aniline (assay 99%), ammoniumperoxydisulfate (assay > 98%) and Thiophene (Merck). All chemicals were analytical grade. Double distilled water was used for preparation of various solutions. Nickel sulphate added Polyaniline/Polythiophene was synthesized via an in-situ oxidative polymerization, in which aniline, thiophene and ammonium peroxydisulfate (APS) were used as monomer and initiator, respectively. Initially, aniline and thiophene was dispersed in 1 M HCl by vigorous stirring at room temperature after 10 minutes 0.5M nickel sulphate was added. Then APS (0.25 mol) was dissolved in 1 M HCl and dropped into the reactor. After dropping the initiator, the mixture was kept constant stirring for 24 h. After the reaction, a dark green precipitate resulting from the polymerization reaction was filtered and washed with distilled water and acetone sequentially in order to remove the excess initiator, monomer and oligomer. This precipitate is then dried in an oven at 60°C for 24h.

3. Results and Discussion

3.1. Morphology Analysis

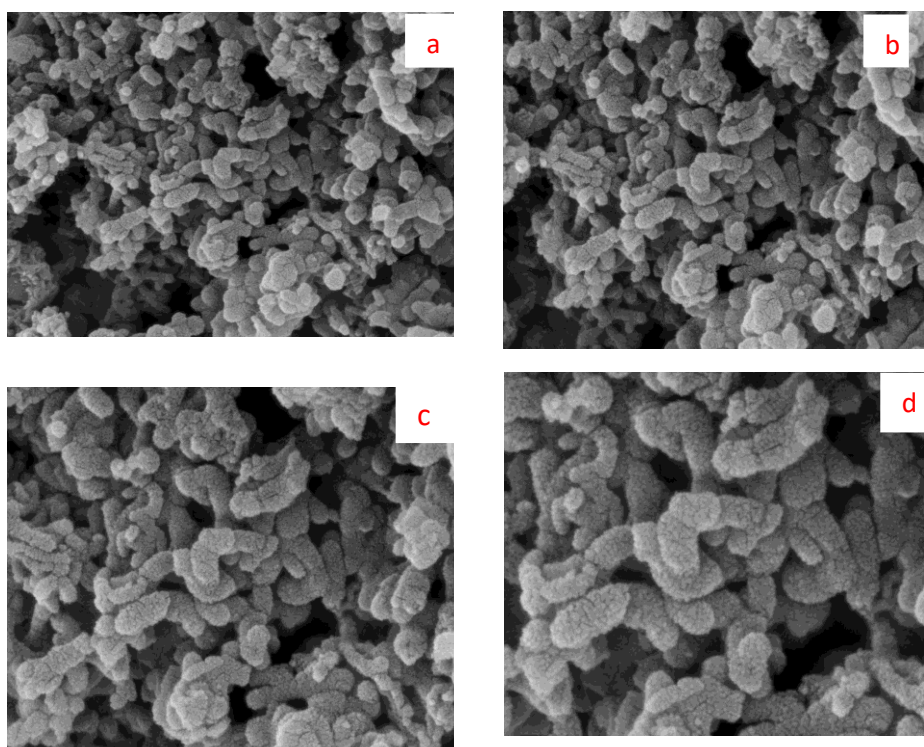


Fig.3.1. (a) to (d) FESEM images of Polyaniline-Co- Polythiophene-Ni

The surface morphology of as prepared sample was analyzed with the help of Carl Zeiss SUPRA-55 model field emission scanning electron microscope. The FESEM analysis fig3 (a) to (d) of the Polyaniline-Co-Polythiophene-Ni shows the Nano-capsule like structure with 70 nm diameter. The morphology of polythiophene has nearly spherical in shape where as polyaniline has fiber like nanostructure. The FESEM image shows that the spherical polythiophene nanoparticles were encapsulates the polyaniline nanofibers then form the nano-capsule like structures with small aggregation this is due to the presence of nickel oxide on the surface of the polymer matrix. Such nanostructure will increase the specific surface area of active material, enable the electrolyte to penetrate into the cavity of capsule, shorten the diffusion path for both electron and electrolyte ions and finally improves the electrochemical performance for supercapacitor [13] and electrical circuits

3.2. X-ray diffraction Analysis

The crystalline nature of the samples was tested with the X-ray diffraction analysis using Bruker D8 advance. Fig2. Shows the XRD pattern of Nickel sulphate added Polyaniline-Co-Polythiophene-Ni nanomaterial with sharp and noisy peaks in 2θ range $18^\circ - 30^\circ$. Sharp peaks are the characteristics peaks of Ni cluster, which present in the surface of boundary of grains. The sharp peak at 19° attributed the NiO_2 particle corresponding to intermolecular $\pi - \pi$ stacking. The XRD pattern exhibits the amorphous diffraction peaks as well as crystalline peaks so the as prepared Polyaniline-Co-Polythiophene-Ni composites acquires semi-crystalline phase with peaks between $20-25^\circ$ indicate that the Ni cluster present on the surface of polymer matrix[16-18].

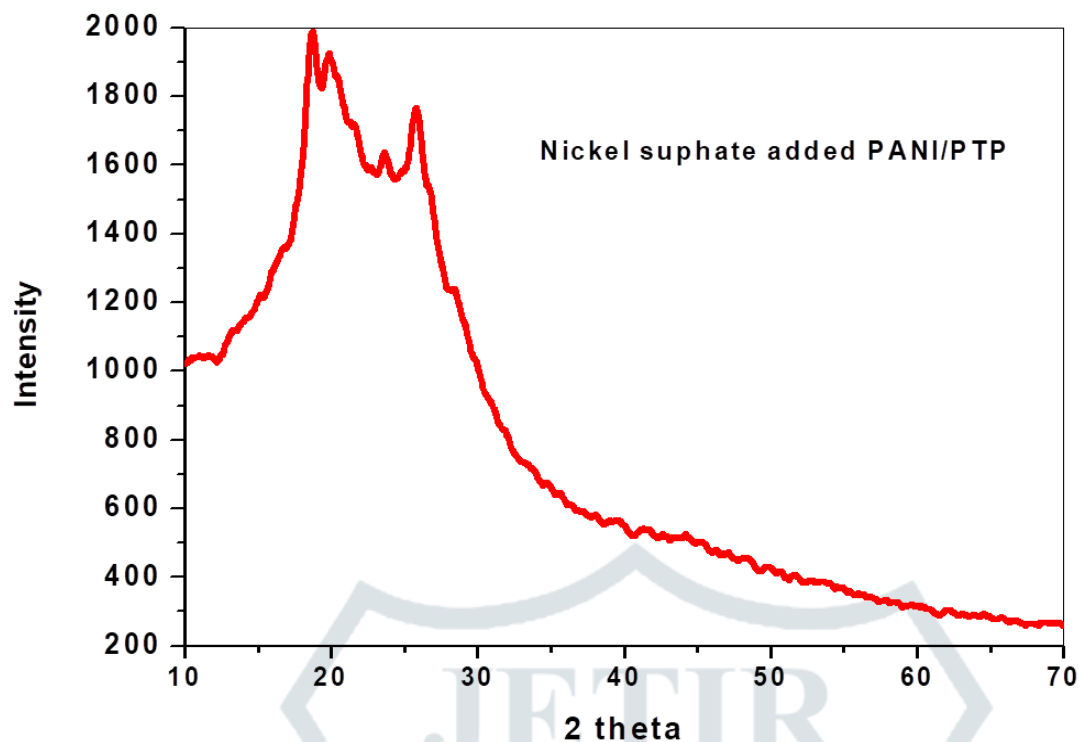


Fig.3.2. X-ray diffraction Spectra of Polyaniline-Co- Polythiophene-Ni

3.3.FT-IR Analysis

Functional groups of the as prepared sample were analysed using SCHIMADZU IR affinity1 from Analytical. Fig1. Shows the FT-IR spectra with characteristics peaks of Polyaniline-Co-Polythiophene-Ni

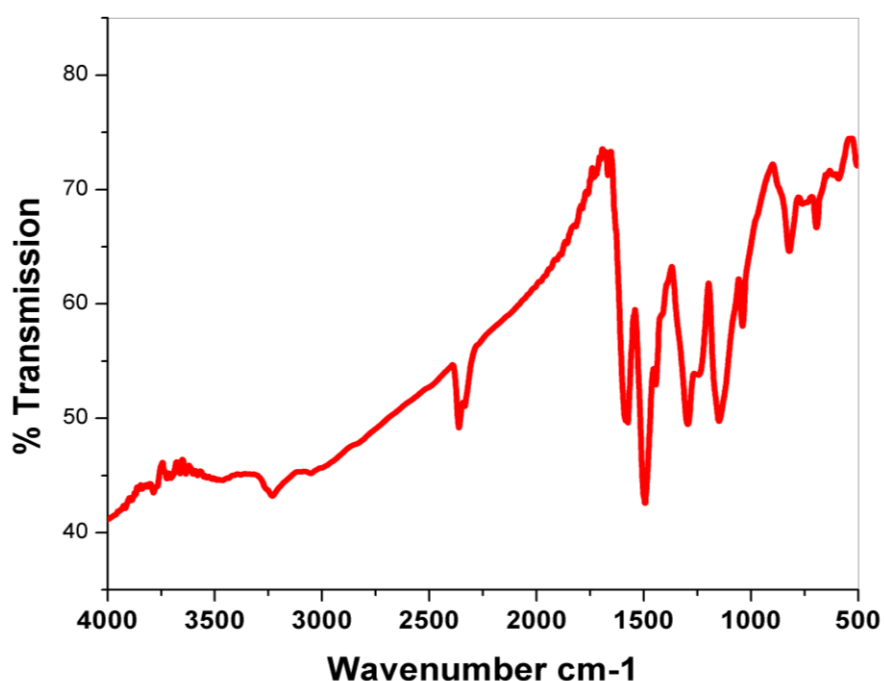


Fig.3.3. FT-IR Spectroscopy of Polyaniline-Co- Polythiophene-Ni

at 1585 cm^{-1} and 1494 cm^{-1} corresponding to C=C stretching vibration. The peaks at 296, 1143 & 1036, 819 and 750 cm^{-1} corresponding to N-H stretching of benzenoid ring, in plane C-H bending, out plane C-H bending, C-S bending vibration respectively. The peaks between $3037\text{--}3250\text{ cm}^{-1}$ corresponds to N-H and C-

H stretching vibration. The peaks between 686 to 426 cm^{-1} confirms presence of nickel oxide in the PANi-co-PTh matrix.

3.4. UV-Visible Spectroscopy

The UV-Vis absorption spectra of the samples in N-methy-2-pyrrolidone solvent were recorded in the range of 200 – 800 nm with a photometer (Agilent UV Carry 60). Fig.4 shows the absorption spectra of PANI/PTP with peaks at 280 , 316 , 360 and 578 nm . The absorption peaks at 280 , 316 and 360 nm correspond to π – π^* transitions of the thiophene and aniline ring. The peak at 578 nm is due the charge-transfer-excitation-like transition from the highest occupied energy level to the lowest unoccupied energy level and the π – π^* transition in PANI and PTP. The absorption bands at 225 , 255 and 280 nm is due to the nickel nanoparticle and these peaks confirm the presence of nickel²⁰ in the PANi-co-PTh polymer matrix.

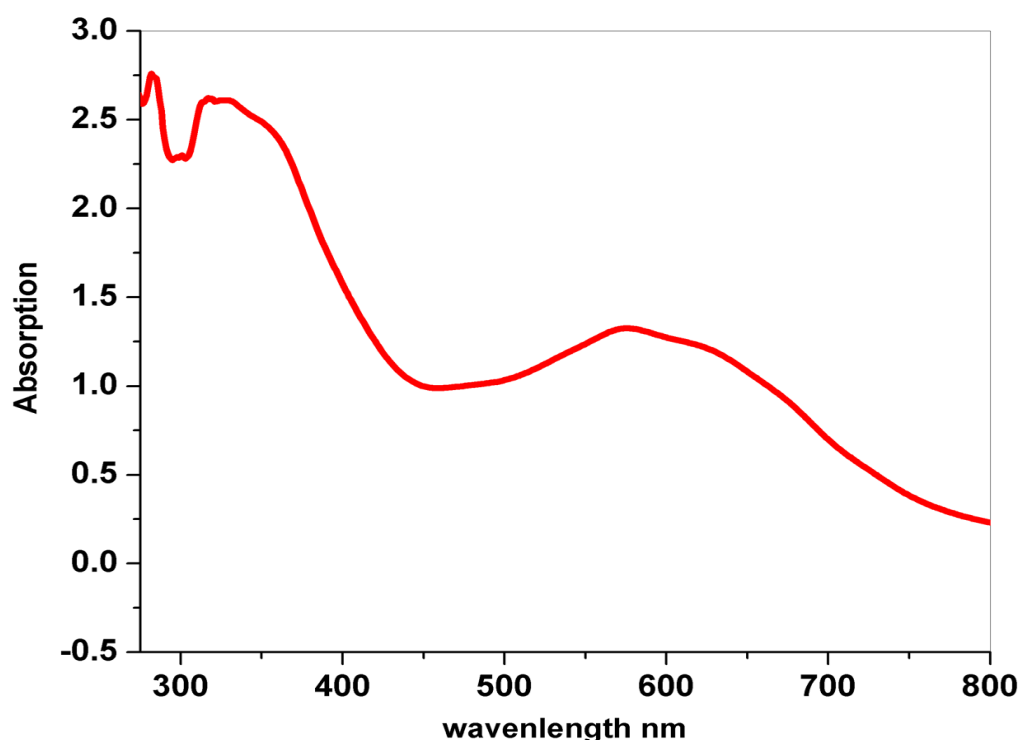


Fig.3.4. UV-Visible absorption spectra of Polyaniline-co-polythiophene –Ni nanocomposite

3.5. I-V Characteristics

The current-voltage characteristic curves of an electrical device or component used to define its operation in electrical circuits. The current - voltage measurements were performed using autolab FRNA. I-V characteristic of Polyaniline-Co-Polythiophene-Ni nanocomposite is shown in fig5. It reveals that, the I-V characteristics between -10V to $+10\text{V}$ has been linear and the charge transport was due to mobility of polarons and bipolarons apart from electron and holes. So the nanocomposite can be used as ideal resistor in electrical circuits as part of motor controls, in power distribution systems, test loads for generators, sensing devices for heat, light, humidity and chemical activity because high-power resistor can dissipate many watts of electrical power as heat[24-25].

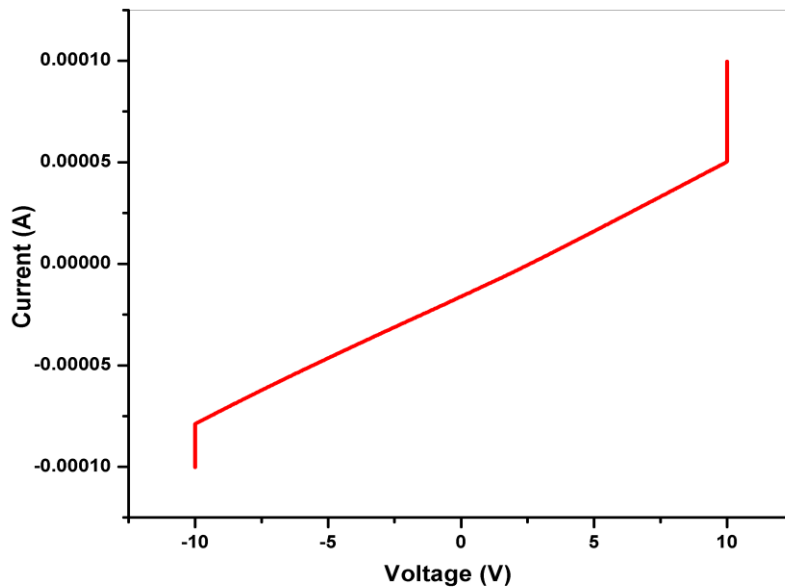


Fig.3.5.V-I Characteristics of Polyaniline-co-polythiophene –Ni nanocomposite

3.6. Zeta Potential

The zeta-potential is an important parameter of the electrical double layer and represents a characteristic of electrical properties of solid/liquid and liquid/gaseous interfaces. The zeta potential of Polyaniline-Co-Polythiophene-Nickel sulphate was -46mv. This result showed that Polyaniline-Co-Polythiophene-Nickel nanocomposite has chemical good stability to the colloidal suspensions this is due to the long polymer chain increases the mechanical linkage between the single particles [23].

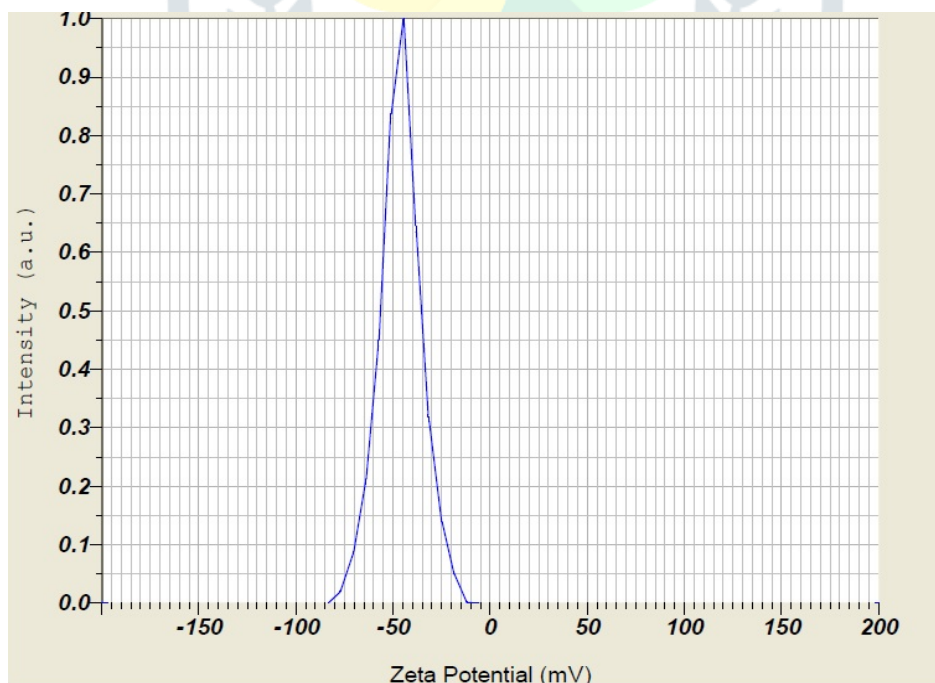


Fig.3.6. Zeta Potential of Polyaniline-co-Polythiophene-Ni Nanocomposite

Conclusion

Polyaniline-Co-Polythiophene-Ni nanocomposite was prepared by in-situ chemical oxidation method. FESEM images showed nano-capsule like structure with average diameter 70 nm. I-V characteristics showed ohmic behavior of nanocomposite. The UV-absorption bands at 225, 255 and 280 nm confirmed the presence of nickel in the PANi-co-PTh polymer matrix. I-V characteristics of nanocomposite reveal that can be used as ideal resistor in electrical circuits. And Polyaniline-Co-Polythiophene-Nickel sulphate nanocomposites has good stability to the colloidal suspensions.

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