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Electrical Applications of Synthesized Graphene-Polyaniline Conducting Nanocomposite

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Abstract

Over the past 30 years, Conducting polymers (CP) are the significant element for researchers because of their stability, workability, lighter weight and its ability to resist corrosion. The objective of this paper is to eradicate the limitations of the conducting polymers and replace these materials with newly emerging materials known as 'Nano-composites' because of their superior electrical and mechanical properties. The various naturally occurring inorganic nanomaterials which are when combined with conducting polymers leads to the generation of a host of nanocomposites which has fascinating properties as well as adequate application potential. In this paper, synthesis of Graphene/Polyaniline nanocomposites are synthesized and their characterization with SEM, FT-IR analysis, UV analysis and electrical conductivity with two probe.

Keywords: Graphene; Polyaniline; Nanocomposites; Conducting polymer;

1. Introduction

Conducting polymers are increasing replacing natural and inorganic materials application requiring excellent mechanical properties and lightweight. Conducting polymers are peculiar in that they conduct current without having a partially empty or partially filled band. The different excitations in conjugated polymers differ in the charge they carry: a positive/negative: Polaron is an excitation that carries a single positive/ negative electron charge. A Bipolaron is a double charged excitation; an exciton is a neutral excited state, which in simplistic way, can be described as carrying a dipole. Conducting polymers either have a zero energy band gap or a very low band gap. The optical band gap controls the electronics and the optical properties of conducting polymers [1]. A reduction in the optical band gap increases the conductivity of the polymers.

Among all the conducting polymers, polyaniline (PANI) is one of the most intrigued materials owing to its ease method of preparation and its high stability towards environmental exposition. Polyaniline exists in several oxidation states with electrical conductivity varying progressively from 1-10S/cm. Polyaniline (PANI) exists in a variety of forms that differ in chemical and physical properties. Depending on the method of preparation, polyaniline bases may exist in a fully reduced form (Leucoemeraldine), partially reduced form (emeraldine) and fully oxidised form (pernigraniline).But in the past few years, polyaniline has attracted great attention because of high degree of ordering and enhanced charge carrier's mobility [2-3].

Polymer nanocomposite owns such a credit due to their significant improvement in properties resulting from the incorporation of a small quantity of conducting polymer. Graphene is a 2D structure consists of sp^2 hybridised carbon atoms, in which the atoms form a flat sheet just one atom thick [4-6]. Graphene show very high electrical conductivity at various conditions because of high electron mobility [7-9]. In this paper, Graphene-polyaniline nanocomposite were synthesized at (9:1 ratio) and further these nanocomposite were characterized by SEM, FT-IR, optical and electrical properties.

2.Experimental Details

2.1.Chemical details

Graphite powder, $NaNO_3$, H_2SO_4, $KMnO_4$, H_2O_2, hydrazine hydrate, Aniline, HCl, Copper sulphate, ammonia solution were used as received from Sd-fine chem. Ltd., India. The water used throughout all experiment was double distil water. All solutions were made by double distill water and used as a stock solution.

2.2 Preparation of Graphene oxide and Graphene

A modified Hummer's method was used to synthesize Graphene oxide (GO) from graphite powder [10]. In this process, 46mL of 98% sulphuric acid was added to 1gm of graphite powder and stirred for a period of 24hrs in an ice bath. After this 100mg of $NaNO_3$ was added to the mixture and stirred for another 30mins.Then 3gm of $KMnO_4$ was added slowly to the blend in a stepwise addition at 20 °C. 75mL of water was added and stirred for 2hrs at 95 °C. The obtained mixture was centrifuged to remove the existing raw graphite and is finally dried in an hot air over to obtain graphene oxide. This obtained GO was further mixed and deionised water (1:2) ratio and sonicated for 2hrs for obtaining exfoliated graphene oxide.

The obtained GO was mixed in 100mL of water and to this, hydrazine hydrate was added. Then the solution was heated in an oil bath to 100 °C for 24hrs. Finally, the obtained product was isolated with series of filtrations with water and methanol and dried in air to obtain graphene.

2.3 Synthesis of Polyaniline and Graphene/Polyaniline nanocomposite

In a typical reaction, 0.2 gm of aniline was dissolved in 10ml of methanol in a 25 ml conical flask. To thiscontinuously stirred solution, 0.5 ml of cupric sulphate solution (10^{-1} mol/ dm^3) was added drop by drop. During the addition, the solution took on a green colourization. At the completion of adding copper sulfate, a parrot green precipitation was observed at the bottom of the conical flask. The entire reaction was performed at room temperature under continuous stirring conditions by using magnetic stirrer.The Preparation of polyaniline/Graphene nanocomposites was done by using the magnetic stirrer and mixing the (9:1, Graphene:Polyaniline) and then filtered and dried. The Graphene/PANI composites were made by taking different weight ratios of polyaniline and graphene and further pelletizing it by cold pressing at a pressure of 6 tons using a hydraulic press. The pellets were made with Graphene/PANI different compositions of 9:1, denoted as J_1.

2.4 Characterization

These synthesized Graphene/PANI were characterized by SEM with EDS (energy dispersive spectrometry), FTIR spectroscopy, Uv-visible spectroscopy and Kiethley two probe.

2.4.1 SEM of Graphene/polyaniline nanocompsite

In the scanning image the nanocomposites inherit the network structure. The nanocomposites experimented smooth surfaces. The figures below show the morphology of sample J1. The nanocomposites were found in the range of 1µm which is equivalent to 1000nm at 20,000 magnifications, 0.5 µm is equivalent to 500nm at 50,000 magnifications, 5 µm is equivalent to 5000nm at 5000 magnification and 1 µm is equivalent to 1000nm at 10,000 magnifications as shown in Figure 1. For nanocomposite, SEM image shows that all the graphene sheets are homogeneously coated with PANI and the PANI mainly grown on the surface or intercalate between the graphene sheets. The SEM images reveal that the graphene and the PANI formed a uniform composite with the PANI absorbed on the graphene surface and/or filled between the graphene.EDS analysis was described in Table 1, 2 and 3.

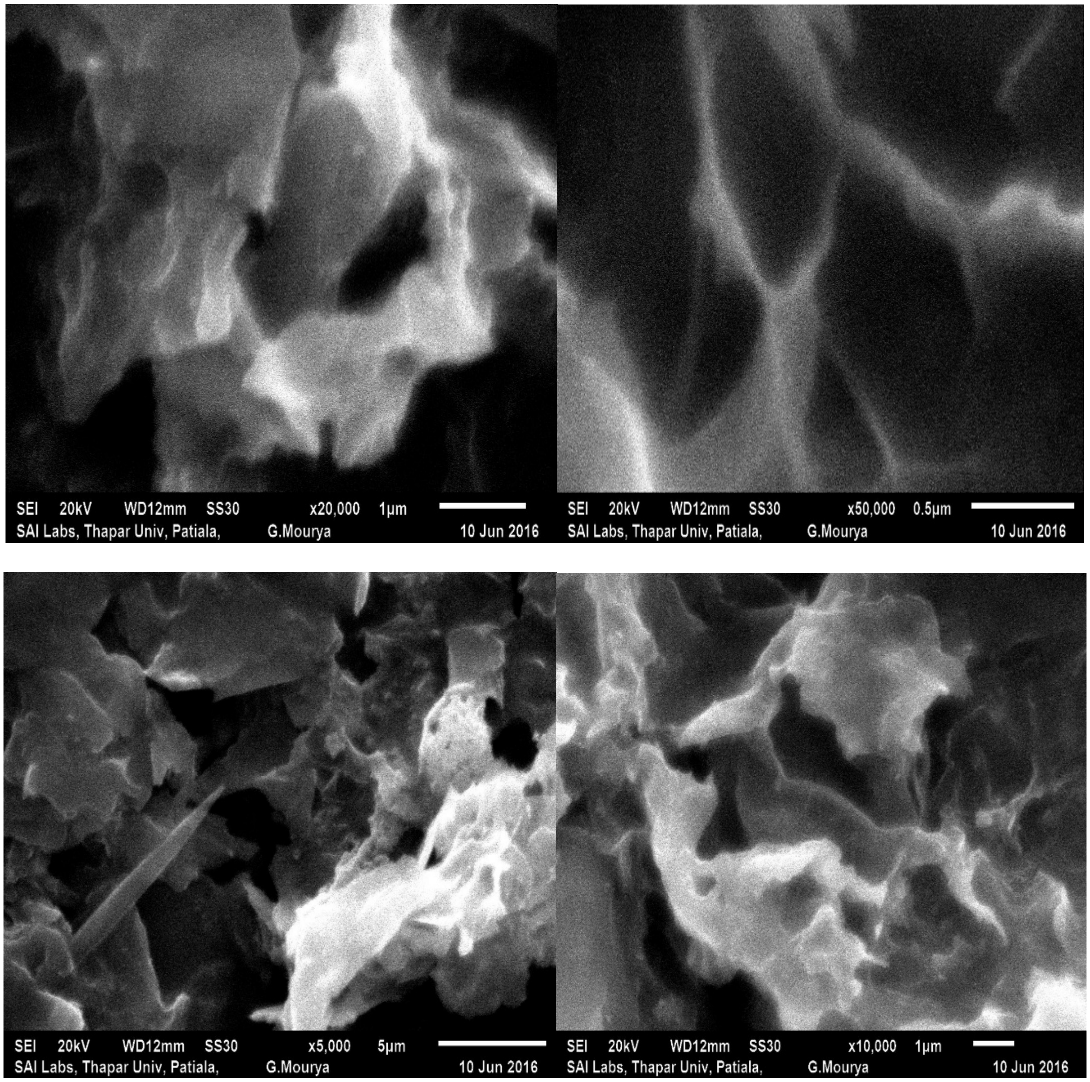

Figure 1: SEM of sample J1(graphene/polyaniline) at magnification of (a) 20,000 (b) 50,000 (c) 5,000 (d) 10,000

Table1: Compositional Description of Sample J1 for Spectrum 1 (EDS analysis)

Element	**Weight%**	**Atomic%**
C K	46.69	60.38
N K	07.29	8.08
O K	26.94	26.15
S K	03.01	1.46
Cu K	16.07	3.93
Totals	100.00	

Table2: Compositional Description of Sample J1 for Spectrum 2 (EDS analysis)

Element	**Weight%**	**Atomic%**
C K	48.12	59.49
N K	10.75	11.40
O K	27.26	25.30
S K	2.50	1.16
Cu K	11.37	2.65
Totals	100.00	

Table3: Compositional Description of Sample J1 for Spectrum 3(EDS analysis)

Element	**Weight%**	**Atomic%**
C K	48.23	61.49
N K	5.74	6.28
O K	28.05	26.85
S K	4.45	2.13
Cu K	13.53	3.25

Totals	100.00	

2.4.2 Fourier Transform Infrared of Graphene-polyaniline nanocomposites.

FT-IR spectroscopy is used to record FT-IR spectra. It is a technique to obtain an infrared spectrum of emission, absorption, photoconductivity or Raman scattering of a Gas, Liquid or solid. FT-IR spectroscopy produces a qualitative analysis of a different material such as organic and inorganic.

FT-IR is an effective instrument for diagnose a covalent bonding and identify the functional groups. Stretching peak at 3239 cm^{-1} is due to the OH group and NH_2 group showed the stretching peaks 3346 cm^{-1}. 1697 cm^{-1} is due to C=O without conjugation and 1487 cm^{-1}, 1596 cm^{-1}, 1100 cm^{-1}, 1286 cm^{-1} are due to C=C due to conjugation in polyaniline backbone, C=C due to graphene backbone, C-O-C stretch. 2326 cm^{-1} stretching vibrations due to C=C=O. C-H bending vibration 749cm^{-1} is observed. FT-IR spectrum shown in Figure 2.

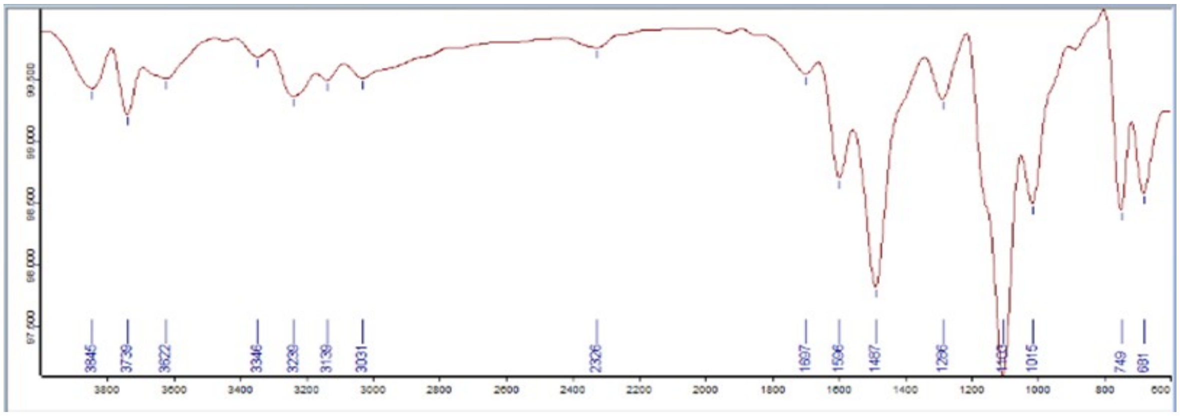

Figure 2: FT-IR spectrum of J1 sample (Graphene/polyaniline).

2.4.3 Electrical Conductivity Measurement

Keithley two probe electrical system was used to confirm the electrical behaviour of graphene/polyaniline nanocomposite. From this analysis it is confirmed that as increased the content of Graphene the electrical conductivity increase. This nanocomposites show more electrical conductivity than alone polyaniline and graphene. Voltage to current graph shows that current is varying linearly as the applied voltage increase. The highest peak is obtained at points 30.000E^{-6}, 24.000E^{-6} and 40.000E^{-6}. Electrical conductivity in Figure 3.

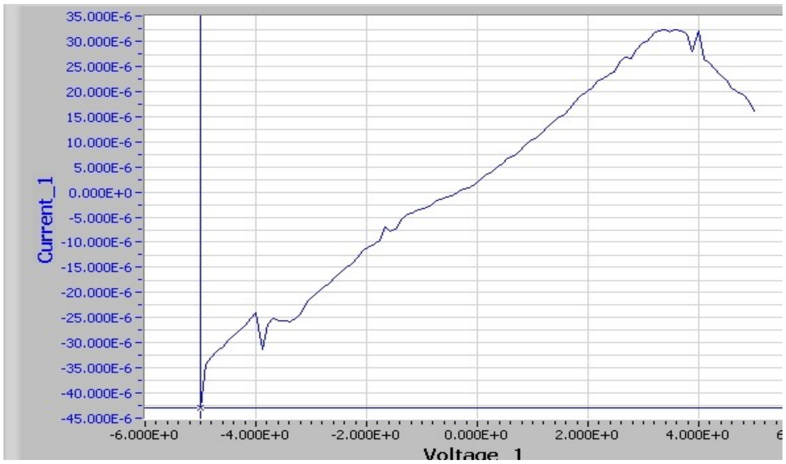

Figure 3: Electrical conductivity of Graphene/Polyaniline sample J1 using two probe system at first positions.

2.4.4 UV-Analysis

UV-analysis was employed for the quantitative analysis of nanocomposites. This analysis represents the optical properties of the samples. It represents the reflectance spectroscopy or absorption spectroscopy in the ultraviolet-visible spectral region. The perceived color of the chemicals involved is directly affected by the reflectance or absorption in the visible range. Molecules undergo electronic transitions in the region of the electromagnetic spectrum. Through absorption spectrum, the transitions from the ground state to excited state were measured. Band gap of Graphene/Polyaniline is E=1240/320 = 3.8 eV.

2.4.5.Study of Conductivity Results

The electrical conductivity of the samples was measured that has shown that the electrical conductivity of the samples gradually increases in order with the increase in voltage along with the increase in current. Voltage to current graph shows that current is varying linearly as the applied voltage increase. But it is not entirely linear. There are few disruptions near the zero voltage. The highest peak is obtained at points $30.000E^{-6}$, $24.000E^{-6}$ and $40.000E^{-6}$.

3. Conculsion

In this paper, we have synthesized the Graphene/polyaniline nanocomposites and from the band gap decreases as compared to graphene alone. These nanocomposites shows better properties than the polyaniline and also results show that the conductivity of the graphene samples was increased to great extent. Morphological analysis was done through qualitative and quantitative analysis of graphene samples. The electrical properties of these are shows metal like properties. Results show that nanocomposites have a better structure as irregularities were decreased to a great extend as compared to the compared to conducting polymers. It has been resolved from the results of an investigation that nanocomposites are much better for the synthesis of nanosensors than conducting polymers due to their good conducting properties compared to conducting polymers. Results from this investigation shows that such nanocomposites could be used for energy storage application like supercapacitors.

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