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Insights into the structural, optical, thermal, dielectric, and electrical properties of PMMA/PANI loaded with graphene oxide nanoparticles

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ABSTRACT

Polyaniline nanofibers (PANI NFs) was prepared by Interfacial and rapid-mixing polymerization Fourier transform infrared (FTIR), X-ray diffraction (XRD) and Scanning Electron Microscope (SEM) were used to examine of pure nanofibers. The structural, optical, thermal, and conductivity properties of pure blend and PNCs were studied by using FTIR, XRD, SEM, UV–Vis., DTA-TGA, and Ac conductivity measurement techniques and have been prepared using the casting method. The analysis of FT-IR reflects forming hydrogen bond between the PANI and PMMA. Also it's confirmed the presence interaction between GO NPs with the functional groups of PMMA/PANI matrix. The XRD data revealed the increase of amorphous domains of nanocomposites comparing to that of the pure polymer blend. The SEM indicates the uniform distribution of GO NPs on the surface of the prepared samples. From UV. Vis showed the values of optical energy gap (direct and indirect) for pure blend and nanocomposites decreases with increasing content of GO NPs. Based on DTA and TGA data, the thermal stability of all the investigated samples were improved and the activation energies were calculated. Electrical conductivity analysis indicates that the 0.9 wt % sample have a larger conductivity compared to that of prepared samples. The increase in conductivity was mainly due to the increase in mobility of charge carrier according to free-volume model.

1. Introduction

There are various applications depend on polymers in many fields such as scientific, industrial and medical fields. Some applications are embedded into first generation such as anticorrosion, static coating electromagnetic shielding. Other applications such as solar cells, LEDs, batteries, transistors, etc are embedded into second generation. All of these materials can be attractive through some factors such as high temperature resistance, controlled conductivity, ease of bulk preparation and low cost [1,2].

Due to many factors such as, chemical stability, unique doping behavior, good electrical conductivity, abundant morphology, and relatively, attention is paid for Polyaniline (PANI). These factors allow PANI for various potential applications such as sensors, storage, electrochemical energy, microelectronic devices, and protection of metallic corrosion. Recently, nanofibers have grasped the attention of researchers due to the possibility of developing and enabling its applications in the field of nanotechnology [3–5]. There are two methods for PANI nanofibers (PANI NFs) to synthesize electrochemically or chemically through both template or without template methods. Adding metal oxides is very important to modulate the properties of PANI NFs [6]. The importance of Polyaniline nanofiber is due to the degree of high stability, simple ways of synthesis, and effectiveness of electrical conductivity manage through converting both the protonation condition or the oxidation condition and lastly the low cost of the aniline monomer [7–9]. PANI can be either insulating or conductive, based on the oxidation condition and protonation stage. According to the state of intermediate oxidation, the protonated emeraldine shape, are conductive PANI nanofibers have great attention because of their superior properties [10]. PANI nanofibers have various applications, including electric devices [11], flash welding [12,13], rechargeable batteries [14], electromagnetic shielding devices and anticorrosion coating [15].

One of the most famous methods of polymer modification is through combining two or more elements with different properties [16]. Blending of polymer is an attractive method for producing new polymeric materials with tailored properties without having to synthesize totally new materials. Other advantages for polymer blending are versatility and simplicity [17]. Poly (methyl methacrylate) (PMMA) is widely used in many technological applications due to the special blending of good optical properties, good mechanical properties,

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electrical properties, thermal stability, resistance of weather and easy shaping. One of the best optical materials which is organic is PMMA. It has been utilized in order to make a variety of optical devices, such as optical lenses [18].

A great attention has been directed to Graphene; which is a two-dimensional form of graphite, due to the high surface area, conductivity, and excellent mechanical properties. Graphene oxide (GO) is a single sheet of graphite oxide and the surface includes some functional groups (carboxyl, hydroxyl, epoxy group, etc.) on their basal planes and edges [19]. The GO has good material to synthesize functional nanocomposites due to good compatibility with polymer [20]. Furthermore, graphene oxide also has larger specific surface area, wide chemical potential, excellent chemical stability, and rich drape morphology [21]. The conductivity of the electrode, will be developed after compound graphene oxide to polymer. Therefore, combining nanometer-sized and nanostructured graphene oxide with PMMA/PANI composite has been extensively studied. The aim of this work is to improve the structural, optical and electrical properties PMMA/PANI NF nanocomposites films are incorporated into graphene oxide (GO) layers as potential candidate for electrochemical device applications.

2. Experimental work

2.1. Materials

Poly (methyl methacrylate) (PMMA) polymer with molecular weight 100,000 was obtained from BDH chemicals, England. Chloroform supplied by Aldrich Co. was used as solvent. Graphene oxide (GO) (was supplied from Sigma-Aldrich.) nano-powders are unique nanoparticles containing short stacks of graphene sheets with a platelet shape. The average thickness of Graphene oxide nanoparticles is around 10 nm. Aniline (99.5%) was supplied by Tianjin Bodi Chemical Co., Ltd. Aniline (S. D. Fine Chemicals, India), sodium nitrate, toluene, hydrogen peroxide (H_2O_2), hydrochloric acid (HCl).

2.2. Preparing PANI nanofibers

By the existence of hydrochloric acid as a catalyst and ammonium-peroxidisulphate like an oxidant, Polyaniline has been combined by means of in-situ chemical polymerization of aniline. At approximately 0 °C temperature, for the combination, 50 ml, 1 M HCl and 2 ml of aniline have been brought into a 250 ml glass container prepared with Teflon coated magnetic stirrer. Followed by 5 g of ammonium perdisulphate ($(NH_4)_2S_2O_8$) aqueous solution in 50 ml 1 M HCl has been put in drop wise into the above solution. The polymerization temperature 0 °C has been kept for 10 h to finish the reaction. After that the result in received was filtered. The product was washed in succession through 1 M HCl accompanied with double distilled water until the wash solution have become with no color. The product PANI has been dried at 60 °C for 24 h to obtain powder shape PANI. This powder became pelletized with the assist of hydraulic machine for description.

2.3. Characterization of PANI nanofiber

Interfacial and rapid mixing methods prepared Pure polyaniline nanofibers, while, the PANI nanocomposites were concocted via fast blending approach. Examination of the organized nanofibers was brought out by Scanning Electron Microscope, X-ray diffraction and FTIR. The existence of the typical absorption peaks of PANI in the FTIR spectrum indicates a success polymerization of aniline through interfacial or fast blending techniques and nanocomposites, as displayed in Fig. 1a. The X-ray diffraction proves the structure of PANI nanofiber, two typical peaks round 2Θ = 20.3° and 2Θ = 25.2° shown in the XRD type of the PANI nanofibers Fig. 3 a, the similar XRD type was gotten by other researchers [22]. Consistent with the surveys reported by Ref. [23] the nanofibers are in partial crystallinity. The partial crystallinity

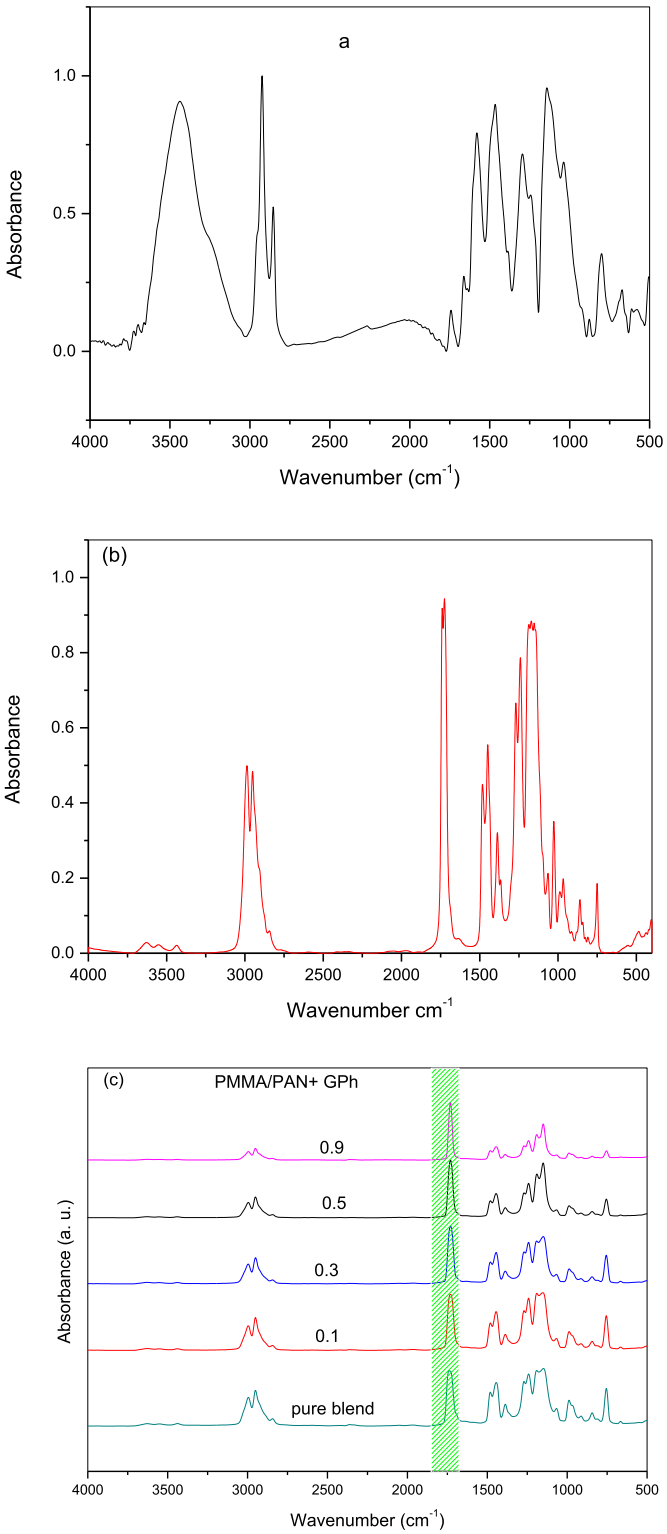

Fig. 1. FTIR spectra of pure (a) PANI, (b) PMMA and (c) PMMA/PANI/GO nanocomposites.

of polyaniline nanofibers can be because of the amine and imines collections within the formation of doped PANI that may shape more potent inter molecular and intra molecular hydrogen bonds. SEM pics of PANI NFs (Fig. 4b). After completion of polymerization by using interfacial and fast-blending strategies in addition to nanocomposites.