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A Polymer Composite Film from Gum Arabic and Ferrous Sulphate Doped Boron Nitride

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Abstract: ***The present work details to the preparation of a polymer composite film using Gum Arabic and ferrous sulphate doped boron nitride. The exfoliated Boron nitride sheets were doped with ferrous sulphate and filled in to the Gum Arabic polymer matrix. This composition is then solvent casted to a film.***

Keywords: Boron nitride, Gum Arabic, Polymer composite, Exfoliation, Solution mixing

1. Introduction

Polymer composites formed by adding natural or synthetic filler materials in minimal quantity to a polymer matrix as a future promising new material with. Enhanced properties. Boron nitride (BN) is a chemically layered substance, white in colour where in each layer has equal number of boron and nitrogen atoms held strongly by covalently bonds and the inter layers are held by weak Van-derwaal's bond.

Boron nitride, a fascinating material on which researchers pay interest in recent times is due to its interesting properties which includes high thermal, chemical and electrical stability [1]. Due to immense properties Boron nitride are widely used in many industrial applications that includes space applications, paint and cosmetic industries [2] and also in manufacturing of high temperature equipments and semiconductor devices. Many studies revealed in tuning the properties of boron nitride that directed its installation for wider applications. Tuning the chemical hardness associated to the boron nitride nanosheets by doping it with carbon emerges in increasing the absorption capacity and thus could be used for mechanical applications [3].Tuning of the electronic and optical properties of single-layer boron nitride by strain and stress enriches its properties which could inturnbe used in optical and electronic equipments [4]. Tuning of the electronic, optical and associated magnetic properties of boron nitride nanosheets using oxygen doping results in the production of improved quality that enhances the usage of BN nanosheets in many applications [5].

PLA/BN composite films preparation by the method of solution casting showed the influence of BN concentration on the morphological, mechanical and thermal characteristics of the composite films and the further studies indicated high tensile strength of the composite incorporated with BN, a modest degree in the degradation temperature of the composite, an enhancement in the plasticity characteristics of PLA that allows the movement of chain segments, an improvement in mechanical properties and hence exhibited that PLA/BN composite material could be widely used in packaging applications [6]. Polydimethylsiloxane / BN polymer composites pointed improved thermal conductivity properties that attributes in enhancing the structural characteristics of the polymer [7]. Polycarbonate/BN polymer composite films depicted a higher performance in heating and cooling rate due to good heat conduction resulting in the production of a highly thermally conductive and mechanically strong material applicable in thermally managed applications [8].

Ferrous sulphate ($FeSO_4 \cdot xH_2O$), a chemical substance coloured bluish green, being odourless is usually a good reducing agent. Gum Arabic is a natural biopolymer branched-chain multifunctional hydrocolloid with a highly neutral or slightly acidic, arabino-galactan-protein complex containing calcium, magnesium, and potassium [9] extracted from the stem and branches of Acacia Seyal and Acacia Senegal trees. Acacia senegal and Acacia seyal is considered the best in quality due to a low quantity of tannins and comprises the majority of global trade [10], whereas Acacia seyal produces a lower grade of Gum [11]. Acacia trees are abundant in central Sudan, central and West Africa, and tropical and semitropical areas of the world [12]. Gum Arabic as an adhesive when wrapping mummies and in mineral paints for making hieroglyphs are reported [13]. In modern times, they are used in foods, pharmaceutical, and many other industries [14]. Exfoliation technique is one of the major methods used for the conversion of bulk materials in to layered forms. Here bulk boron nitride material is exfoliated to form layered material (BNNS). Main solvents used for the exfoliation process are DMF (dimethyl formamide) or distilled water. Ferrous-sulphate doped boron nitride is used as a filler to modify the properties of gum Arabic polymer to form a polymer composite.

2. Methodology

This gives an insight into the preparation of Boron nitride nanosheets, its doping with Ferrous-sulphate ($FeSO_4$) and blending of the treated Boron nitride with Gum Arabic polymer to form polymer composite film. All chemicals (Boron Nitride, $FeSO_4$ powder. Gum Arabic) used in the experiment are of Analytical grade and were purchased from Sigma Aldrich, USA (99% purity). Deionized water was used for the synthesis purpose and for washing and cleaning distilled water was used throughout the experiment. The flowchart (see Fig 1), represents the experimental procedure followed to prepared the polymer composite film.

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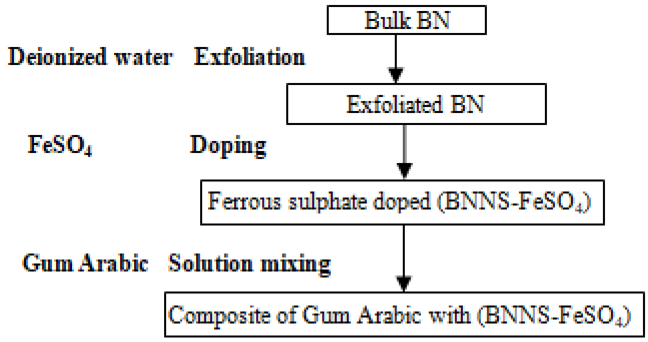

Figure 1: Flow chart for the preparation of sample

Synthesis of Boron Nitride Nanosheets

Liquid phase exfoliation method is employed herein for the preparation of Boron Nitride nanosheets. In the present study, 1.5gm of bulk Boron Nitride was dispersed in 250ml of deionised water by continuous stirring for about 20 minutes. This solution was subjected to sonication using a probe sonicator for 60 minutes (see Fig 3). Then the solution was kept undisturbed for a day for the bulk particles to settle down. Now the supernatant solution was centrifuged and the dispersed boron nitride sheets were separated and collected by filtering. This was then washed several times using distilled water to remove the impurities if any present. The Boron nitride sheet which was then collected was kept in an oven at a temperature of 60^0C. The dried white powder taken out from the oven was grinded well and kept in safe lock covers for further analysis.

Doping of Boron nitride nanosheets

In the present study, the Boron Nitride Nanosheets thus synthesized by the method of exfoliation discussed above was doped using $FeSO_4$. 1.5 gm of $FeSO_4$ powder was dissolved in 150ml of deionised water and stirred well for uniform dispersion. The exfoliated Boron nitride nanosheets was dispersed in it and stirred continuously for 2hours. Then the solution was kept undisturbed for a day until the bulk particles settled down. Then the supernatant solution was separated and centrifuged. On centrifugation, the higher density particles settle down and the lower denser particles are dispersed in the solvent, which was filtered, washed and then collected. The collected samples were then kept in oven at about 60^0C, till it got dried. The dried samples after collection was kept in a crucible and further placed in muffle furnace at 400^0C for about 6hours to remove further unwanted impurities in the sample. The collected samples were finely grinded using a mortar pestle. Thus ferrous-sulphate doped Boron Nitride Nanosheets (BNNS-$FeSO_4$) was obtained.

Synthesis of polymer composite blend of Gum Arabic and (BNNS-$FeSO_4$)

In the present study, the ferrous sulphate doped boron nitride sheets (BNNS-$FeSO_4$) was used as fillers in the Gum-arabic polymer matrix. At first 1.5 gm of gum-arabic was dissolved in 150ml deionized water and to this solution different weight percentages (**2 wt%** [0.02gm], **4wt $^0/_0$** [0.04gm], **6wt%** [0.06gm]) of BNNS-$FeSO_4$ was added by continuous stirring. This was then casted on to a petridish and dried in oven for about 48 hours at 65°C to obtain the polymer composite film.

3. Results and Discussion

Bulk Boron nitride shown in Fig 2 (a) was exfoliated in to Boron nitride nanosheets as photographed in Fig. 2 (b). The Boron nitride nanosheets thus synthesized was doped using $FeSO_4$. The ferrous-sulphate doped boron nitride nanosheets (BNNS-$FeSO_4$) shown in Fig 2 (c) was used as fillers in the Gum-arabic polymer matrix. Gum-arabic was dissolved in deionized water and to this solution different weight percentages (2 wt%, 4 wt% and 6 wt%) of BNNS-$FeSO_4$ was added by continuous stirring (Fig 2 (d)). This was then casted on to a petridish to obtain the polymer composite film (Fig. 2 (e)).

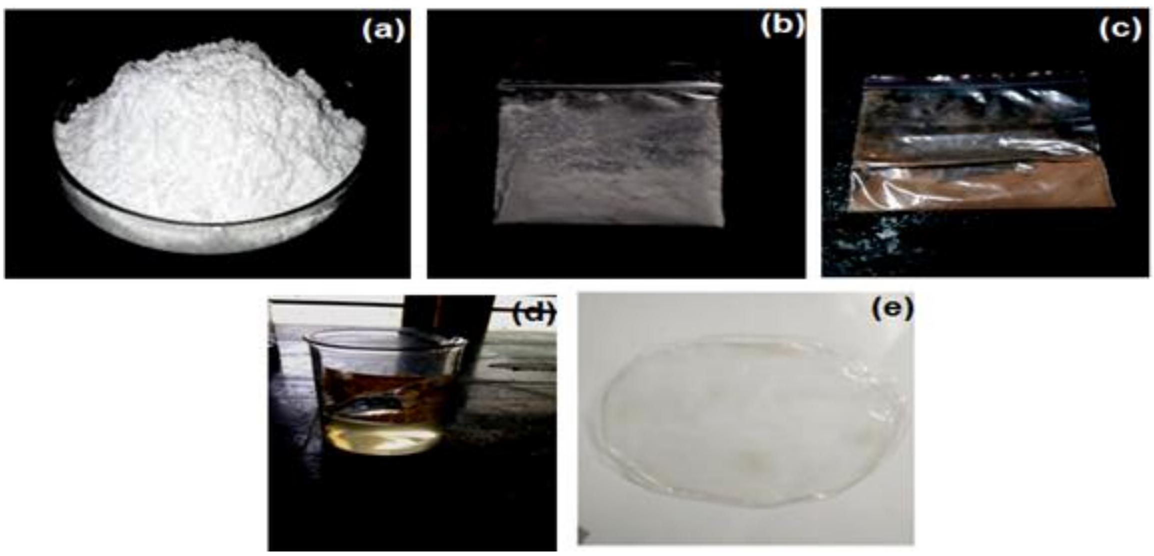

Figure 2: Photographs of (a)Bulk BN powder (b)exfoliated BN sheets (c) ferrous-sulphate doped BN sheets (d) BNNS-$FeSO_4$incorporated Gum arabic polymer solution (e)Prepared Polymer composite film.

4. Conclusion

Boron Nitride sheets and ferrous sulphate doped BN sheets were successfully prepared by the method of liquid phase exfoliation by using deionized water. Further, the work confirmed the preparation of a composite film from gum-arabic polymer in which the ferrous-sulphate doped BN sheets were incorporated as fillers into Gum-arabic matrix. This composite film can be examined for various property studies in the future work.

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