INVESTIGATIONS OF FLEXURAL AND HARDNESS BEHAVIOUR OF GRAPHENE COMPOSITES

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Abstract. In this paper, it was investigated about the flexural and hardness behaviour of graphene reinforced with hemp fiber composites. Hemp fibres with graphene of two different laminates are prepared. Epoxy resin of grade LY556 along with hardener HY 951 is blended with graphene composites through a hand layup method. The mechanical properties of graphene reinforced NaOH treated and untreated hemp fibre laminates are tested for their efficiency. Results indicate that Graphene when it is reinforced with hemp fibre, the mechanical properties namely flexural and hardness behaviour are enhanced to a greater extent. These composites have various academic and engineering fields.

1. Introduction

Qiaoling Wang et al. [1] studied and regenerating process of ischiadic nerve of rats, and procures the basics for the clinical application of nano materials and combined to isolate the extracellular matrix of ischiadic nerve of rats with graphene oxidized. By using Hummer’s Method, graphene oxidized is generated by the addition of potassium permanganate to a solution of graphite, sodium nitrate and sulphuric acid. To scan and detect the functional groups in graphene oxidized of sample Fourier IR spectrum and by using the pellet method, the microcosmic morphological appearance of graphene oxidized was observed by using the scanning electron microscope. Graphene oxidized/decellularized scaffolds were prepared by the use of oscillation mixing method and operation bridging of injured ischiadic nerves was conducted [2]. Comparisons among groups were analysed by variance, and the comparison of two means was detected. Graphene oxidized could combine with the biomaterial-decellularized scaffold to repair the injury of ischiadic nerve and regenerating process of injured nerve. This provided new thoughts and theoretical & experimental bases for nano materials to be applied to clinic treatment. Azraai et al. [3] experimented that, by adding graphene nano platelets is added with the epoxy grouts and following test namely tensile, compressive and flexural test was carried out to study the effect of graphene-epoxy based composites. By comparing graphene based and epoxy grout, the results showed same strength was observed on both the cases due to the weak interface in graphene nano platelets and epoxy composites.
By performing the tensile and flexural test, the results showed Graphene based epoxy grouts is slightly lower than ones of neat epoxy grout [4]. The graphene has improved the strength, ductility of the grout, hence reducing its brittle behaviour. Wu et al. [5] investigated about the effect of mechanical properties and strain induced on crystallization behaviour on natural rubber/graphene oxide composites. In order to analyse the oblique size of graphene oxidized, to fabricate the natural rubber/graphene oxide nano composites we use various sizes of graphene oxidized sheets. Adding graphene oxidized can increase the modulus of natural rubber. Dynamic mechanical measurement and swelling ratios ($Q_f/Q_g$) indicate that it has stronger interfacial interaction with Natural Rubber. XRD shows more effective in accelerating the strain-induced crystallization of natural rubber. The strong interfacial interaction facilitates the stress transfer and strain induced crystallization, both of which lead to the improved modulus.

Rutkowski et al. [6] observed that by applying pressure methods sintering of alumina-graphene material takes place. By making different combinations of graphene with alumina followed by processing in hot pressing or spark plasma sintering. The microstructural properties are studied under Scanning Electron Microscope (SEM). The various measurements of mechanical and elastic properties were carried by ball-on-disk method. Vijaya Ramnath et al. [7] determined the mechanical properties of intra-layer abaca–jute–glass fiber reinforced composite. The composite is made up of five layers with three layers of jute and abaca enclosed by two layers of glass fibers. The composites are manufactured with three different fiber orientations and the compositions are varied in three different proportions. The fabricated composite samples are tested to investigate their various mechanical properties.

Xusheng Du et al. [8] studied that the formation of graphene/epoxy composites was made by simple thermal reduction method from functionalized graphene sheets as a raw material. The graphene incorporated with epoxy showed better fracture energy to withstand and reduction of thermal expansion coefficient to lesser value. Partially cured G/E composites were used as interleaves in carbon fiber/epoxy (CF/E) composites and co-cured an increase in interlaminar fracture energy to a greater extent. The damage sensing capacity of the graphene and its electrical response method was demonstrated, where the change in electrical resistance increased almost linearly with crack increment. Rajesh Kumar Prusty et al. [9] investigated the effect of graphene oxide in glass fiber/epoxy composites at elevated temperature environments. Present investigation shows the effect of environmental temperature on the mechanical response of glass fiber/epoxy (GE) composite loaded with a range of graphene oxide content. Presence of GO in the composite significantly strengthens the fiber/matrix interface as well as the matrix. Good dispersion of GO is achieved up to 0.5 wt%.
Exposure to elevated temperatures deteriorates the flexural properties of GE as well as GO modified composites but the extent of degradation remains higher in case of GO-GE composites [10]. The storage modulus increases with increasing GO content up to 0.5%. Therefore, GO incorporation may not always strengthen polymeric composites rather it depends on the environmental temperature. Due to high thermal conductivity of graphene-polymer composites, it can be used as an interfaced link for the applications [11]. This paper talks majorly about modulating the graphene-polymer interfacial thermal transport. By using molecular dynamics simulations, the analysis showed that there was a covalent functionalization of graphene that could considerably reduce the graphene-polymer interfacial thermal resistance [12]. To reduce the thermal resistance, we can use butyl groups and also it is most effective.

Jijun Tang et al. [13] studied the properties of Graphene Oxide/Epoxy Resin Composites. The graphene oxide was obtained by pressurized oxidation method using natural graphite as raw materials. The epoxy resin composites were prepared by casting. The glass transition temperature decreased and the damping capacity is improved. Graphene oxide significantly enhances the toughness of the composites while it does not decrease the strength of the composites. As the graphene oxide content is 0.5 weight, the impact intensity of the composites reaches the largest value when compared with pure epoxy resin matrix, and the damping capacity is improved. Vijaya Ramnath and et al. [14] investigated the Shear and Hardness of Abaca based Hybrid composite fabricated by hand layup process. Abaca fiber has more strength than other fibers like Kenaf, banana and sisal, the composite with this fiber can be suitable replacement material for automotive applications. The properties like double shear and hardness were evaluated and the result shows that the double shear properties and hardness of the hybrid composites [GFRP +Abaca+Raffia] is higher than other two combinations.

2. Materials used

2.1 Hemp fiber

In this work, Hemp fiber has been used as reinforcement that can be used for various applications like paper, textiles, clothing, biodegradable plastics, paint, insulation, biofuel, food, and animal feed. Normally, the hemp stalks would be water-retted first before the fibres were beaten off the inner herd by hand known as scratching which is nowadays replaced by crushing rollers and brush rollers Many commercial products are made as composite sink, rope, jewellery and bio fuels.
2.2 Graphene

Graphene is an allotrope of carbon in the form of a two-dimensional hexagonal lattice, it is about 200 times stronger than the commercial steel. It efficiently conducts heat and electricity and is nearly transparent.

2.3 Epoxy and Sodium Hydroxide

In this work epoxy is used as resin matrix which is largely petroleum derived. The resin used for this study is Epoxy Resin with brand name of LY 951 which is manufactured by fibre Glass Development Corporation Company. It has superior flexural strength and adhesive characteristics and fatigue resistance. Also, sodium hydroxide (NaOH) also known as lye and caustic soda is an inorganic compound used in this work to treat the hemp fibers.

3. Methodology

The conventional methods like retting, water retting are used for chemical treatments. After treatment drying and combing of fibers were done to make it ready for fabrication.

3.1 Hand layup Method

It is an easy and simple method of fabricating natural fiber composites. Even though the production is very slow, it suitable for all types of fibers. In this work, the layup process involves manipulating each ply into shape by hand and then firmly stuck to the previous layer or mold surface leaving no air pocket between plies. This can produce high quality complex features, has relatively low start-up costs, and is highly adaptable to new parts and design changes. However, it is far from perfect, as production rates can be low and the costs of both materials and labour are sometimes high.

4. Testing of composites

The following tests were performed on the fabricated composites as per ASTM standard.

4.1 Flexural Test

Flexural tests are generally used to find the flexural modulus or flexural strength of a material. The material is laid horizontally over two points of contact and then a force is applied to the top of the material through either one or two points of contact until the sample fails. The maximum recorded force is the flexural strength of that particular sample. The specimen is prepared as per ASTM D 790 standard.
4.2 Hardness Test

Hardness is a measure of how resistant solid matter is to various kinds of compressive force. The Rockwell method measures the permanent depth of indentation produced by a force/load on an indenter.

5. Result and Discussion

The following section gives result of mechanical test carried out in this work namely flexural and hardness.

5.1 Flexural Test

The results of flexural test for treated and untreated specimens are furnished in Table 1.

| SPECIMEN                        | FLEXURAL LOAD |
|---------------------------------|---------------|
| HEMP FIBER + GRAPHENE (untreated) | 0.42 kN       |
| HEMP FIBER (NaOH) + GRAPHENE (treated) | 0.49 kN       |

Figure 1. Result of Flexural Test (untreated)
It is seen that flexural load capacity is high for specimen 2 which has been treated with NaOH and high potential graphene. It is noted that fiber treatment increases flexural load carrying capacity which is nothing but flexural strength of the fabricated composites. The Figure 1 represents the results of specimen at various stages of flexural test of untreated fiber and the Figure 2 represents the results of specimen at various stages of flexural test of treated fiber.

5.2 Rockwell Hardness Test

The hardness test results of treated and untreated specimens are tabulated. The test has been performed with 1/16 ball indenter with 100 Kg load. The results indicated that hardness have been partially increases by treating the fiber.

| SPECIMEN                  | ROCKWELL HARDNESS NUMBER |
|---------------------------|--------------------------|
| HEMP FIBER + GRAPHENE     | 32 HRB                   |
| HEMP FIBER (NaOH) + GRAPHENE | 35 HRB                   |
6. Conclusion

In this work hand lay process is used to fabricate hemp fiber reinforced natural fiber composites. Two types of composites namely treated and untreated laminate were fabricated. Flexural and hardness properties were evaluated. It was concluded that fiber treatment improves flexural and hardness of composites.

7. References

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