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Study and Experimentation of the Mechanical Characteristics and Bio-Degradability of Bio-Composite

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Abstract

Composite materials and alloys are replacing the conventional materials, because of their superior properties. On the other hand, these materials should be recyclable and should not lead to any pollution. So bio derived products witnessed an exponential growth for producing materials with lower environmental impact. In this research, bio composite had been be prepared by using bio resin (Shorea Robusta seed oil) as matrix material and jute fibre as reinforcement .Their mechanical properties such as tensile strength, flexural strength, and Impact strength have been studied and compared. Scanning electron micrograph (SEM) images also taken to observe the characteristics of dispersion, fibre bonding and matrix crack. Also bio degradability test and water absorption test also conducted. The result proved that the prepared matrix having very good mechanical properties and pollution free bio-degradable properties.

Introduction

A composite is made to inherit the best properties of two or more materials with arbitrary properties and results with unique properties. Composites are having heterogeneous structures to meet the design and functional requirements imbued with desired properties. These properties can be achieved by using fibers of structures like filled, flake, particulate and laminar composites and thus this type of fibers act as reinforcing material to withstand maximum load carrying capacity and to achieve the desirable properties. In order to hold these fibers, resins have been used and are called as matrix. In matrix-based composites, the matrix materials have to be selected to optimally distribute the stresses among the constituent reinforcement materials under the applied load conditions. The load can be temperature variations, conductance, resistance, moisture sensitivity, force, pressure, etc. Commonly used resins are polyester, epoxy, and other specialty resins that can be natural or artificial resins. The properties of the industrial and consumable goods are produced by using catalyst or curing agent and also by hybridizing some additional fiber reinforcement.

Researcher are focusing in different types of composites, because due to their heterogeneous structure which provides unlimited possibilities of obtaining any characteristic behavior, ease of manufacturing, repair ability, corrosion resistance, durability, adaptability, cost effectiveness, etc. so now-a-days, usage of composite because very popular starting from sports goods to space applications. Thus a necessity arises to identify a composite with high quality, less cost and should be easily recyclable. The major recyclable composites are categorized under natural composites and very few in synthetic composites. Natural composites are extracted from plants and animals. These types of composites can also be called as green composite, due to environmental friendly characteristics. So in this research jute fiber has been used to study the characteristics. The property of the fiber will excel only with the suitable matrix

material, its interfacing, area of contact, etc. in this research, the objective of selecting the matrix materials is by considering the chemically inert and non reactive. So Shorea Robusta seed oil, which is a bio-resin has been used and experimental results proved that the properties are better.

Literature survey

Wei Wei Qu, et al[1] conducted experiments on bio composite was originally fabricated with biodegradable polymer PBS and jute fibre, and the effects of fibre surface modification on characteristics of jute fibre and mechanical properties of the bio composite were evaluated. Jute fibres are treated by 2% NaOH, 2 + 5% NaOH for surface modification. Tensile testing, flexural testing SEM is done. The experimental results show that surface modification can remove surface impurities and reduce diameter of jute fibres. Ramesh et al [2] studied sisal–jute–glass fibre reinforced polyester composites is developed and their mechanical properties such as tensile strength, flexural strength and impact strength are evaluated. The interfacial properties, internal cracks and internal structure of the fractured surfaces are evaluated by using SEM. P. Asokan et al [3] reviewed about Bio composite, Bio fibres Bio binders. It is vital important to understand about the properties of biodegradable composites and raw materials used in making such composites which are being used for biomedical, automobiles, packaging and other engineering applications application. J.C. Benezet et al [4] focused on recycling potential of some waste materials, such as olive pits etc. Then the powder is introduced in a bio based and bio degradable matrix at various percentage .In this study, reveals that with filler loading, an increase in the tensile modulus but a decrease of flexural strength may be due to poor interfacial bonding. Sathish Kumar et al [5] reviewed on hybrid composite, natural fibres, mechanical properties, and thermal properties. The mechanical properties with and without chemically treated fibres were reported. The water absorption capability of the composites and its effect on mechanical properties were also reported. David Hue et al [6] made a comprehensive review on different kinds of natural fibre composite. Mirna et al [7] conducted a short review on bio composite based plant oil range of macro, micro and Nano sized particles and fibres have been proposed as reinforcements/fillers, including organic and inorganic ones, natural or synthetic, in order to give adequate answers to specific requirements. Although, the role of oil-based products may seem modest in some cases (partial replacement of synthetic materials), there is a clear trend to increase the percentage of ‗‗green‘‘-based raw materials the formulations of commodities as well as specialty polymers/composites for high added value applications. Examples of different types of reinforced thermoset and elastomeric bio-composites are presented in this short review. Omar Faruk et al [8] conducted experiment for identifying the overall characteristics of reinforcing fibres used in bio composites, including source, type, structure, composition, as well as mechanical properties were reviewed. Panthapulakkal and Sain et al [9] studied the mechanical and thermal properties of hemp/glass fibre–polypropylene (PP) composite materials. They have observed that the use of hybrid composite material enhance the flexural and impact properties. Naresh et al [10] studied on total world production of rice husk, jute, banana, and coconut fibre. All these natural fibres have excellent physical and mechanical properties, which can be used effectively in the development of Composite materials for various structural applications. The experimental results showed that 15 wt. % banana fibers reinforced composite show optimum mechanical properties. Ravi Chandra et al reviewed on hybrid composites. They are manufactured by combining two or more fibers in a single matrix. Park et al. [12] evaluated the interfacial properties of jute fibre reinforced polypropylene (PP) and modified maleic anhydride polypropylene (MAPP-PP) composites, demonstrating that fibre surface modification by NaOH and silage coupling agent can effectively improve the compatibility of composites. Schneider and Karmaker [13] studied the mechanical behavior of jute and kenaf fiber based polypropylene composites and reported that jute fiber provides better mechanical properties than kenaf fiber. Tobias [14] analyzed the influence of fiber length and fiber content in banana fiber reinforced epoxy composites and reported that the impact strength increased with higher fiber content and lower fiber length. Yuan et al. [15] studied reinforcing effects of modified Kevlar fibre on the mechanical properties of wood-flour/polypropylene composites and observed that the addition of Kevlar Fibre improved the mechanical properties of Wood Flour/Polypropylene composites. Wang et al. [16] studied the mechanical properties of fibre glass and Kevlar woven fabric reinforced composites and observed that mechanical behaviour depends strongly upon the fibre types.

Materials

The Jute fibers are obtained from the ribbon of the stem. Jute is a soft, soft and shiny, with a length of 1 to 4 m and a diameter of from 17 to 20 microns. It is obtained by successively retting in water beating, stripping the fibre from the core and drying. Jute fibres are composed primarily of the plant materials cellulose and lignin. It

falls into the bast fibre category (fibre collected from bast or skin of the plant) along with kenaf, industrial hemp, flax (linen), ramie, etc. The fibres are off-white to brown, and 1–4 metres (3–13 feet) long. Jute is also called "the golden fibre" for its colour and high cash value. Jute fiber has some unique physical properties like high tenacity, bulkiness, sound & heat insulation property, low thermal conductivity, antistatic property etc. Jute is 100% bio-degradable and thus environment- friendly. It is available in India at competitive prices.

Polyester refers to polyethylene terephthalate and is a category of polymers which contain the ester functional group in their main chain. Polyesters include naturally occurring chemicals, such as in the cutin of plant cuticles, as well as synthetics through step-growth polymerization such as poly butyrate. Shorea Robusta Gaertn is a tree commonly known as Sal or shala tree, belonging to the family Dipterocarpaceae. In addition to the Ayurveda system of medicine, this tree is widely used in Umami medicine.

Fabrication

There are numerous methods for fabricating composite components. The mould tool and the fabrication process are shown in the figure 1.

Figure 1: Mold

Figure 2: Resin is added

Figure 3: Catalyst Addition

Figure 4: Removing air bubble

Figure 5: Specimen

Composite fabrication processes involve some form of moulding, to shape the resin and reinforcement. Figure 1 shows the mould used for fabricating the composite. Hand lay-up technique is used for the composite processing and the addition of resin over the thin plastic sheets had been used to obtain the proper surface finish is shown in the Figure 2. Polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener and poured onto the surface as shown in the figure 3. The polymer is uniformly spread with the help of brush. Then Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure and the air bubbles formed inside the layer is removed as shown in the figure 4. The process has to be repeated for each layer of polymer and mat, till the required layers are stacked. After curing, mould can be opened to remove the developed composite. Then the composite is cut into the required shapes for testing and application usage and the test specimen is shown in the figure 5. Then the specimen has been tested for various mechanical properties.

Testing methods

The tensile test specimen has been prepared according to the ASTM D638 standard (160x19x2.8 mm). The testing carried out in UTM by applying tensile force until it fractures. The properties like ultimate strength, yield strength, etc have been calculated and recorded.

The second test carried out was the Flexural test, it is to determine the capability of a material to withstand maximum bending before reaching its breaking point. This test was performed in this research using three point bend test (Instron 1195). Normally, the specimen is loaded while in a horizontal position, and in such a way that the compressive stress occurs in the upper

portion and the tensile stress occurs in the lower portion of the cross section. If the specimen is symmetrical about the mid plane of its cross section (e.g., rectangular), the maximum tensile and compressive stresses will be equal. Thus, whether the specimen fails in tension or compression simply depends on which strength value is lower. For most, but not for all, composites, the compressive strength is lower, and thus the specimen will fail at the compression surface. It is prepared under ASTM D790 (100x12.5x3mm).

The third test performed on the specimen to study the characteristics is the Impact test. It determines the material toughness in the presence of a notch and at fast loading conditions. This destructive test involves fracturing a notched specimen and measuring the amount of energy absorbed by the material during fracture. For this test charpy impact test machine had been used with the specimen size of 1cm x 1cm x 5.5cm with a 2mm deep notch at the middle of a specified flat surface. In this, two types of test had been performed, the first test had been carried out in normal room temperature and the second test had been carried out in low temperature to study the characteristics of the bio composite under different temperature conditions. Low temperature charpy testing involves placing the specimens in a chamber bath of propylene glycol and dry ice.

General properties of the natural fibers are the water absorbing property, so the fourth test performed is to detect the water absorption capability of the composites. Water absorption tests were conducted by immersing the composite specimens in distilled water in plastic tub at room temperature for different time durations, then the specimens were taken out from the water and all surface water has to be removed with a clean dry cloth and the specimens were reweighed. The moisture absorption was calculated by the weight difference. Similarly, the specimens were immersed in water at 100°C to determine water absorption at a higher temperature. All organic polymeric materials will absorb moisture to some extent resulting in swelling, dissolving, leaching, plasticizing and/or hydrolyzing, events which can result in discoloration, embrittlement, loss of mechanical and electrical properties, lower resistance to heat and weathering and stress cracking. The test specimen obeys ASTM D 570 (50x50x3 mm).

In order to interpret the results, it became essential to know the arrangement of fibers inside the matrix materials, so in this work, to identify the alignment and dispersion of the fiber in the matrix materials scanning electron microscope (SEM) has been used. SEM is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. Specimens can be observed under high vacuum, in dry conditions and to the cryogenic or elevated temperatures. The images obtained from the SME are shown in the figure 6.

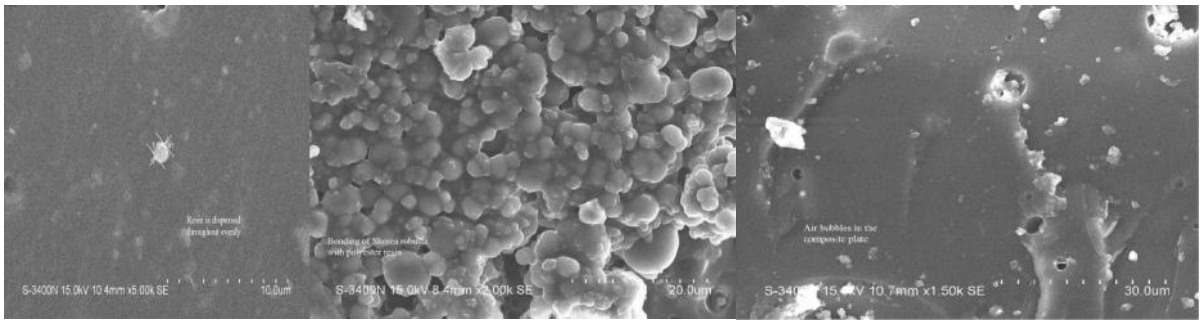

Figure 6: SEM image

The final test performed on the specimen is bio-degradability test. Biodegradation is the chemical dissolution of materials by bacteria, fungi or other biological means. The product which passes this test will be the environmentally friendly products. Biodegradability testing is done to know how much the work piece will decompose. The actual weight of the work piece is being taken and it is being compared with the decomposed work piece as per ASTM standard (50x50x3 mm). The obtained results are discussed in the following section.

Results and Discussion

The range of 26.92 MPa, 22.94 MPa ,20.56 MPa , 19.56 MPa , 18.56 Mpa , 17.92 Mpa 16.56 Mpa respectively. The results indicate the same trend as that of the load vs. displacement curve. From the results, it can be asserted that the jute– Synthetic composite vs. Bio composite are performing well compared to the other type of fibers used and is shown in the figure 7.

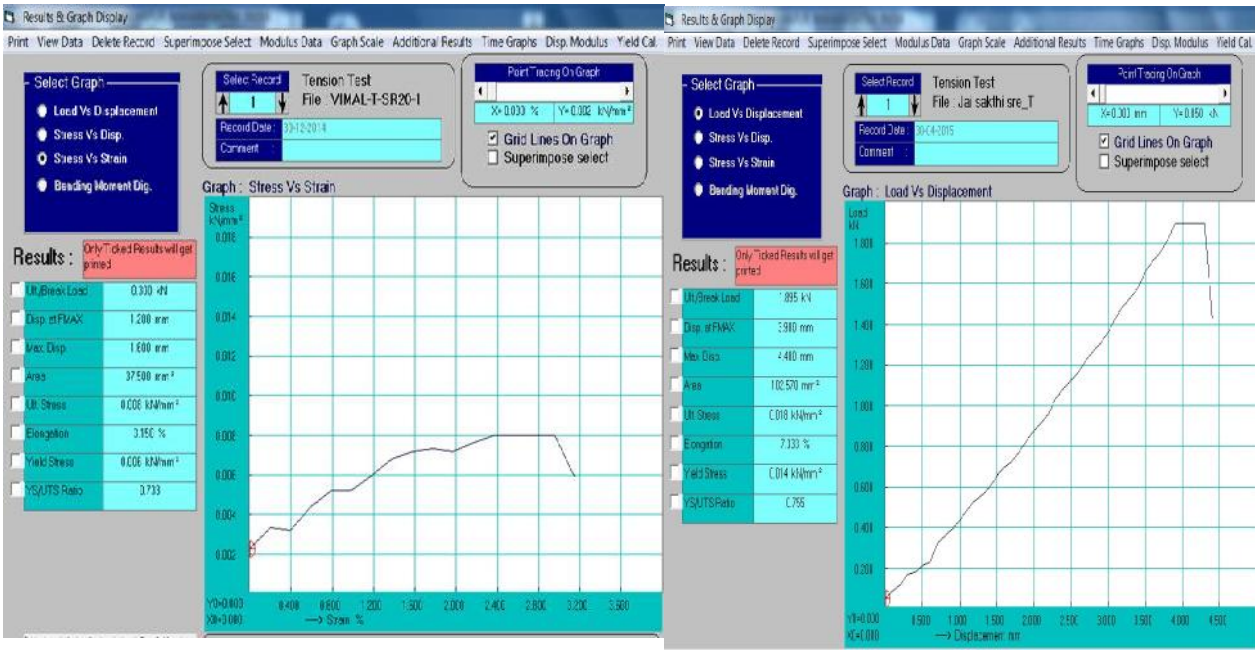

Figure 7: Tensile testing sample graph

The sample graph of flexural strength observed for the jute-Synthetic vs. Bio composites. The result indicated that the displacement increases with the increase of applied load up to around 3000 N, after that, it tends to decrease, i.e., breaking takes place, the maximum displacement observed. The load vs. the displacement graph for different composites tested. The results indicated that the displacement increases with the increase of load. After the 14.2 mm displacement, there is a breaking exist. The results indicated that jute– Synthetic vs. Bio composites shows better result than the other type of composites tested. The stress strain curve observed for jute– Synthetic vs. Bio composites specimen. The result indicated that the strain increases proportional up to after that it tends to reduce. The breaking occurs after the strain rate of 35.8. The comparative evaluation of the stress strain rate observed for flexural/compression test is presented in the figure 8.

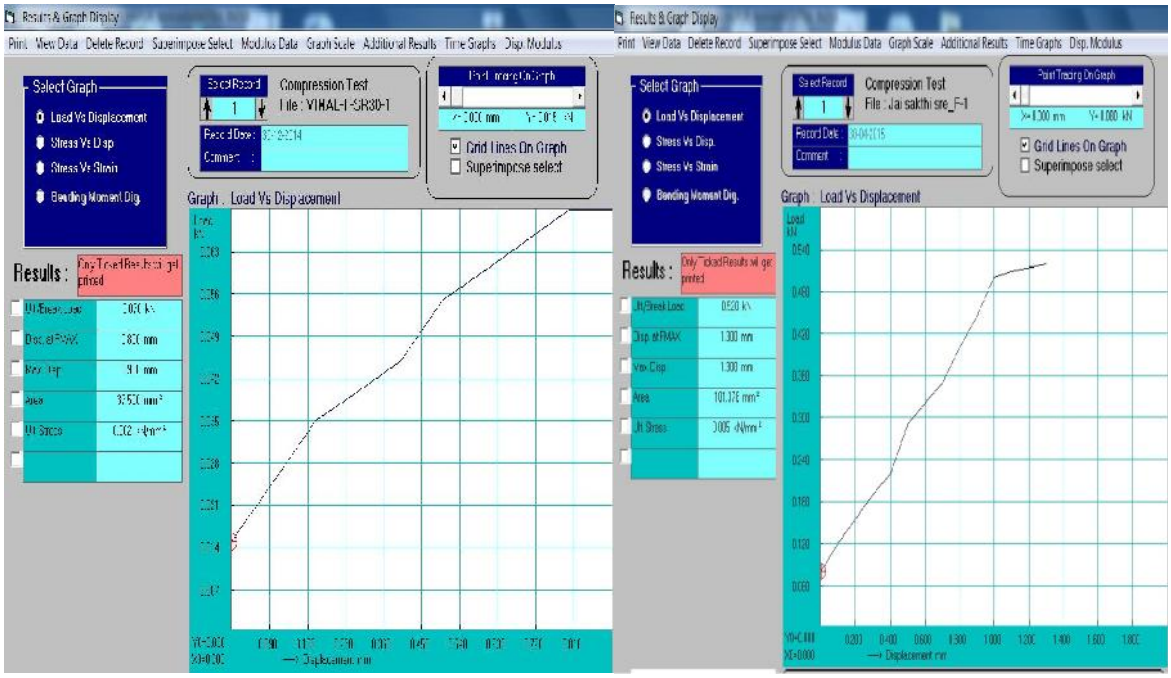

Figure 8: Flexural testing Sample graph

From the figure 8, it is asserted that the jute - Synthetic vs. Bio composites flexural load carrying capacity is better than other composites tested. The composites are capable of taking of the flexural load, The composites shows the performance in between jute– Synthetic vs. Bio composites are capable of taking the flexural testing the following graph are being plotted load vs. displacement. For analyzing the impact capability of the different specimens, an impact test is carried out and the result proved that he impact strength of the bio-composites are better than the jute composite.

The samples were immersed in water to permit the continuation of absorption until saturation limit was reached after 30 days. The weighing was done within 30 s, in order to avoid the error due to evaporation. The percentage of the water content (Mt) was determined. It is found that the water absorption behavior depends on the voids present in the composites, interfacial adhesion between the fibre and matrix, and type of fibres reinforced. The woven basalt fibre composites show higher absorption in normal water compared to sea water. In normal water there are sudden increases in water absorption at the initial stage. After that it gradually increases the rate of water gain. Normal water absorption shows sudden rise in water gain at the initial stage for 4 mm and 21 mm length of fibres. In sea water condition, there was uniform water uptake as shown in 10 mm length of fibre showed better performance than the other fibre length and it was saturated at about hours and is shown in the figure 9.

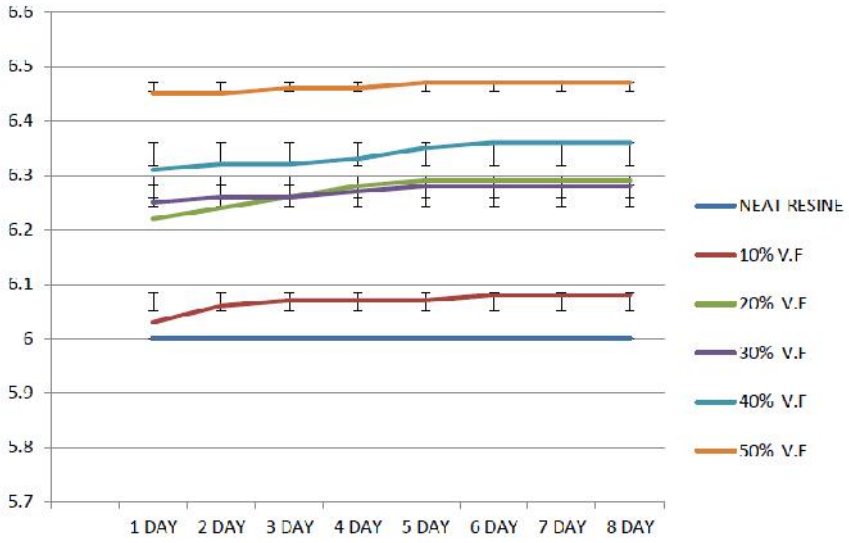

Figure 9: Water absorption graph

Conclusion

The Synthetic composite vs. Bio composite samples are fabricated. The hybrids composite are subjected to mechanical testing such as tensile, flexural and impact test. The interpretations of the results are as follows. Tensile testing for pure resin is around 20.56 Mpa whereas Jute fibre hold strength up to 23.87 Mpa. So the tensile strength has got improved. The flexural testing for pure resin is around 86.66 Mpa after adding reinforcement is around 92.45 Mpa. So the flexural result has got improved. The result indicates that for pure resin the impact strength is around 0.0272 J and after adding reinforcement improved up to 0.04J. The fabricated composite material can absorb up to 6.45 %, where it attains the saturation point. The Specimen is subjected to Bio degradability testing and found that the composite material can decompose up to some mille grams only. This gives an eco-friendly composite. The SEM test proved that the fibers are thoroughly mixed with the resin. Thus the bio composite having many better properties and many advantages, it can be used for the light weight applications.

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