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Fabrication and Experimental Investigation of Banana and Sisal Fibers

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Abstract

Natural fibers, such as sisal, Banana, flax and jute, possess good reinforcing capability when properly compounded with polymers. These fibers are relatively inexpensive, originate from renewable resources and possess favorable values of specific strength and specific modulus. Thermoplastic polymers have a shorter cycle time as well as reprocess ability despite problems with high viscosities and poor fiber wetting. The renewability of natural fibers and the recyclability of thermoplastic polymers provide an attractive eco friendly quality to the resulting natural fiberreinforced thermoplastic composite materials. Common methods for manufacturing natural fiberreinforced thermoplastic composites are injection moulding and extrusion which tend to degrade the fibers during processing. Development of a simple manufacturing technique for sisal fiber, banana fiber composites, that minimizes fiber degradation and can be used in developing countries, is the main objective of this study. Combination of sisal and banana fibers possesses good reinforcing capability when properly compounded with polymers.

Key words: banana, sisal fibers, fabrication, mechanical performance.

1. Introduction

Composites formed are hv combining materials together to form an overall structure that is better than the individual components. Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter or less expensive when compared to

traditional materials. Fiber reinforced polymeric composites have been used for a variety of structural applications because of their high specific strength and modulus compared to metals. Initially developed for the aerospace industry, high-performance or 'advanced' composites are now found in applications from automotive parts to circuit boards, and from building materials to specialty sporting goods. Most composites currently available on the market are designed with long-term durability in mind and are made using non-degradable polymeric resins, such as epoxies and polyurethane, and high-strength fibers, such as graphite, aramids, and glass. Many of these polymers and fibers are derived from petroleum, a non-replenish able commodity. With increasing numbers of applications and mass volume uses, in particular, recording double-digit growth worldwide, disposal of composites after their intended life is already becoming critical, as well as expensive. Because composites are made using two dissimilar materials, they cannot be easily recycled or reused. Most composites end up in landfills, while some are incinerated after use, although there are some efforts to recycle and/or reuse them. Both these disposal alternatives are expensive and wasteful, and may contribute to pollution. In addition, landfills are decreasing in number, making less space available to discard waste. Many applications, e.g. secondary and tertiary structures and those used in consumer products for casing, packaging, etc., do not require the high mechanical properties that advanced composites possess. Since many of the fibers and resins are made using non-degradable, mostly petroleum based materials, once discarded they do not degrade for several decades under normal environmental conditions. This exacerbates the existing ecological and environmental problems. In recent years, the ever-growing worldwide litter problem has raised environmental consciousness among consumers, manufacturers, and governments. Further, it is estimated that we are currently consuming petroleum at an 'unsustainable' rate, 100



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000 times faster than nature can create it. To alleviate these problems, governments in many countries have established laws to encourage the use of recycled and/or bio-based 'green' products. Some governments have enforced strict 'take back' laws requiring manufacturers to take back packaging and products after their intended use.

The growing global environmental awareness and societal concern, high rate of depletion of petroleum resources, concepts of sustainability, and new environmental regulations have together triggered the search for new products and processes that are compatible with the environment. The fibre was washed thoroughly with water and dried in an air oven at 80°C for 6 h, before being chopped into 6 mm length for fibre treatment and the preparation of the composites. Toluene- 2,4-diisocyanate (TDI) and polypropylene glycol (PPG) of molecular weight 1000 were supplied by the Aldrich Chemical Company, USA. Dibutyl tin dilaurate was obtained from Scientific and Industrial Supplies Corporation, Mumbai. Potassium permanganate, sodium hydroxide and maleic anhydride used in the present study were of chemically pure grade [1]. A 10% solution of NaOH was added into the vessel and stirred well. This was kept for 1 h with subsequent stirring. The fibres were then washed thoroughly with water to remove the excess of NaOH sticking to the fibres. Final washings were carried out with distilled water containing a little acid. The fibres were then air dried. The chemical treatment of the sisal fibers has provided considerable improvement of tensile strength when compared to untreated fiber. This is mainly due to transfer of loads among the fibers [2]. The composite CS/SF/BF hybrid composite was prepared successfully and it was confirmed by FTIR, X ray, DSC and SEM analysis. From the above results it is obvious that sorption efficiency was dependent on operating conditions such as pH, contact time, adsorbent dose. The optimum pH for the maximum removal of Cu (II) ion from an aqueous solution is found to be 5.0 [3]. In the present investigation, the effect of moisture absorption of the sisal-coir composites at room temperature and elevated temperatures has been found. It is found that higher fiber content samples have a greater diffusivity because of higher cellulose content. The moisture uptake at elevated temperatures does not show Fickian behavior as compared to room temperature moisture up take behavior. At elevated temperature there is 33% higher moisture absorption

for 40% sisal-coir fiber reinforced composites. The moisture absorption results in this investigation show Fickian behavior at room temperature and non-Fickian at boiling temperature [4]. The use of biodegradable and environment-friendly plant based 'lignocelluloses' fibers has been a natural choice for reinforcing (or filling) polymers (plastics) to make them 'greener'. The availability of inexpensive plantbased fibers in every part of the world has, in part, fueled their use in the past few years. These fibers offer several other advantages as well. They are nonabrasive to processing equipment, can be incinerated, are CO₂ neutral (when burned), and, because of their hollow and cellular nature, perform well as acoustic and thermal insulators. The hollow tubular structure also reduces their bulk density, making them lightweight [5]. In the present investigation, the effect of moisture absorption of the sisal-coir composites at room temperature and elevated temperatures has been found. It is found that higher fiber content samples have a greater diffusivity because of higher cellulose content. The moisture uptake at elevated temperatures does not show Fickian behavior as compared to room temperature moisture up take behavior [6].

2. Problem formulation

The composite material has been used from centuries ago, and it all started with natural fibers. Natural fibers have become important items in the economy and in fact, they have turn out to be a significant source of jobs for developing countries. Natural fibers can be easily obtained in many tropical and available throughout the world. Today, these fibers are assessed as environmentally correct materials owing to their biodegradability and renewable characteristics. For example, natural fibers like sisal, jute, coir, oil palm fiber have all been proved to be good reinforcement in thermo set and thermoplastic matrices. Nowadays, the increasing interest in automotive, cosmetic and plastic lumber application has heightened the need of metallic and plastic materials. In order to overcome these kinds of consequence we are in need of finding alternative materials like natural fibers reinforced composites in these regimes as it offers an economical and environmental advantage over traditional inorganic reinforcements. Therefore, many industrial companies are looking for new composites material which has good and specific properties like mechanical, chemical and dynamic



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characteristic. In searching for such new material, a study has been made where banana and sisal fibers are compounded with composite material.

3. Materials

3.1 Fiber and Resin Selection

Compositing is the combining of visual elements from separate sources into single image often to create the insulation that all those elements are parts of same scene. The parts are,

- Natural fiber
- Resins
- Filler materials

3.1.1 Natural Fiber

Natural fibers have recently attracted the attention of scientists and technologists because of the advantages that these fibers provide over conventional reinforcement materials, and the development of natural fiber composites has been a subject of interest for the past few years.1-4 these natural fibers are low-cost fibers with low density and high specific properties. These are biodegradable and nonabrasive, unlike other reinforcing fibers. Natural fibers include those produced by plants, and geological processes. animals. Thev are biodegradable over time. They can be classified according to their origin. Animal fibers consist largely of particular proteins. Asbestos is the only naturally occurring long mineral fiber.

- Sisal fiber
- Banana fiber

3.1.2 Sisal fiber

Sisal fiber made from the large spear shaped tropical leaves of the Agave Sisal and plant. Fine fiber available as plaid, herringbone and twill. Sisal fiber is extracted by a process known as decortications, where leaves are crushed and beaten by a rotating wheel set with blunt knives, so that only fibers remain. In East Africa, where production is typically on large estates, the leaves are transported to a central decortications plant, where water is used to wash away the waste parts of the leaf. China contributed 40,000 tons with smaller amounts coming from South Africa, Mozambique, Haiti, and Cuba. Sisal occupies 6th place among fiber plants, representing 2% of the world's production of plant fibers (plant fibers provide 65% of the world's fibers). As one of the world's important natural fibers,

sisal is covered by activities of the International Year of Natural Fibers 2009. Proper drying is important as fiber quality depends largely on moisture content.



Figure 1 Sisal Fiber

3.1.3 Banana fiber

Banana is one of the rhizomatous plants and currently grown in 129 countries around the word. It is the fourth most important global food crop. Different parts of banana trees serve different needs, leaves as food wrapping, and fiber and paper pulp. Available in coimbatore. Banana fiber is a multiple celled structure. The lumens are large in relation to the wall thickness. Cross markings are rare and fiber tips pointed and flat, ribbon like individual fiber diameter range from14 to 50 microns and the length from 0.25 cm to 1.3 showing the large oval to round lumen. Banana fiber is a natural fiber with high strength, which can be blended easily with cotton fiber or other synthetic fibers to produce blended fabric & textiles. It is mainly used by cottage industry in Southern India at present.



Figure 2 Banana Fiber

3.1.4 Resin

Resin in the most specific use of the term is a hydrocarbon secretion of manyplants, particularly co niferous trees. Resins are valued for their chemical properties associated uses, such as the production of varnishes, adhesives and food glazing agents.

3.1.5 Epoxy



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Epoxy is both the basic component and the cured end product of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resins, also known as poly epoxides are a class of reactive pre polymers and polymers which contain epoxide groups.

4. Fabrication Process

4.1 Compression Moulding

Compression molding is a method of molding in which the molding material, generally preheated, is first placed in an open, heated mold cavity. The mold is closed with a top force or plug member, pressure is applied to force the material into contact with all mold areas, while heat and pressure are maintained until the molding material has cured. The process employs thermosetting resins in a partially cured stage, either in the form of granules, putty-like masses, or preforms. Compression molding is a high-volume, highpressure method suitable for molding complex, highstrength fiberglass reinforcements. Advanced composite thermoplastics can also be compression moulded with unidirectional tapes, woven fabrics, randomly oriented fiber mat or chopped strand. The advantage of compression moulding is its ability to mold large, fairly intricate parts. Also, it is one of the lowest cost molding methods compared with other methods such as transfer molding and injection molding; moreover it wastes relatively little material, giving it an advantage when working with expensive compounds.

4.2 Mould Preparation

Epoxy LY556 of density 1.15-1.20 g/cm3, mixed with hardener HY951 of density 0.97-0.99 g/cm3 is used to prepare the composite plate. The weight ratio of mixing epoxy and hardener is 10:1. This has a viscosity of 10-20 poise at 2500°C. Hardeners include anhydrides (acids), amines, polyamides, dicyandiamide etc. Mould used in this work is made of well-seasoned teak wood of 290 mm X 290 mm X 3 mm dimension with five beadings. The fabrication of the composite material was carried out through the hand lay-up technique. The top, bottom surfaces of the mould and the walls are coated with remover and allowed to dry. The functions of top and bottom plates are to cover, compress the fiber after the epoxy is applied, and also to avoid the debris from entering into the composite

parts during the curing time. Epoxy is both the basic component and the cured end product of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resins, also known as poly epoxides are a class of reactive pre polymers and polymers which contain epoxide groups.

4.3 Properties of Epoxy Resin (Ly556)

Reactive diluents free matrix system with a very long pot life. The reactivity can be adjusted by varying the accelerator content. The system has very good high temperature performance after post cure and exhibits good mechanical and dynamic properties.

4.4 Fabrication Procedure

The top, bottom surfaces of the mould and the walls are coated with remover and allowed to dry. The functions of top and bottom plates are to cover, compress the fiber after the epoxy is applied, and also to avoid the debris from entering into the composite parts during the curing time. The moulds are cleaned and dried before applying epoxy. The fibers were laid uniformly over the mould before applying any releasing agent or epoxy. After arranging the fibers uniformly, the epoxy resin was applied over the fibers and then they were compressed for a few hours in the mould. Then the compressed form of fibers (banana/sisal) is removed from the mould. Following figures (3-5) shows the three different samples which is prepared by compression moulding process.



Figure 3 Sample 1 (75% Resin 12.5% banana fiber and 12.5% sisal fiber)



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Figure 4 Sample 2 (70% Resin 15% banana fiber and 15% sisal fiber)



Figure 5 Sample 3 (65% Resin 17.5% banana fiber and 17.5% sisal fiber)

5. Material Testing

The mechanical testing of composite structures to obtain parameters such as strength and stiffness is a time consuming and often difficult process. It is, however, an essential process, and can be somewhat simplified by the testing of simple structures, such as flat coupons. The data obtained from these tests can then be directly related with varying degrees of simplicity and accuracy to any structural shape. The test methods outlined in this section merely represent a small selection available to the composites scientist. Some, such as the tensile coupon test, are widely recognized as standards.

5.1 Tensile Test

Specimen for tensile testing has been cut from all samples according to the ASTM D638 standard. This test is used to find the Ultimate Tensile Strength of materials. Tensile testing utilizes the classical coupon test geometry as shown below and consists of two regions: a central region called the gauge length, within which failure is expected to occur, and the two end regions which are clamped into a grip mechanism connected to a test machine. The samples for tensile test are shown in the below fig.6. The samples are prepared under the specification of ASTM-D638.



Figure 6 Tensile Test Specimen

5.2 Impact Test

Before looking at impact testing let us first define what is meant by 'toughness' since the impact test is only one method by which this material property is measured. Toughness is, broadly. A measure of the amount of energy required to cause an item - a test piece or a bridge or a pressure vessel - to fracture and fail. The more energy that is required then the sougher the material. The area beneath a stress/strain curve produced from a tensile test is a measure of the toughness of the test piece under slow loading conditions. However, in the context of an impact test we are looking at notch toughness, a measure of the metal's resistance to brittle or fast fracture in the presence of a flaw or notch and fast loading conditions. It was during World War II that attention was focused on this property of 'notch toughness' due to the brittle fracture of all-welded Liberty ships, then being built in the USA. From this work the science of fracture toughness developed and gave rise to a range of tests used to characterize. Both involve striking a standard specimen with a controlled weight pendulum travelling at a set speed. The samples for impact test are shown in the below fig.7. The samples are prepared under the specification of ASTM-D256-90.



Figure 7 Impact Test Specimen

5.3 Flexural Strength Test



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Flexural analysis was carried out at room temperature through three-point bend testing as specified in ASTM D 790, using universal testing machine. The speed of the crosshead was 5 mm/min. five composites specimens were tested for each sample and each test was performed until failure occurred. Flexural strength was calculated from the Equation.

$$\boldsymbol{\sigma}\mathbf{f} = (\mathbf{3PL}) / (\mathbf{2bd}^2)$$

Where, P = Load at a given point on the load deflection curve in Newton (Peak load)

- L = support span in mm
- b = width of the samples in mm
- d = thickness of the samples in mm.

The samples for flexural strength test are shown in the below fig.8. The samples are prepared under the specification of ASTM D 790.



Figure 8 Flexural Strength Test Specimen

6. Results

6.1 Tensile Test

Tensile test result shows that the Peak load for sample 1 and sample 2 are 817.595 N and 1115.142 N respectively but for sample 1, peak load is 1179.702 N. Ultimate tensile strength for sample 2 and sample 3 are 20.964N/mm² and 28.596 N/mm² respectively but for sample 1 is 30.244 N/mm². From these results it is found that the ultimate tensile strength and peak load of sample 3 is higher than the sample 1 and sample 2. Because of high proportion of fiber gives better load carrying capacity to the sample 3 from among the sample 1 and sample 2.

6.2 Impact Test

Impact test result shows that the sample 3 which contains 35% fiber and 65% resin having more impact value than the sample 1 and sample 2. Because of high proportion of fiber gives good bonding strength to the sample 3 from among the sample 1 and sample 2.

6.3 Flexural Strength Test

Flexural Strength test results show that the flexural strength and peak load for the sample 3 is higher than the sample 1 and sample 2. Among this result sample 2 is highly better than the other two samples. Because of high proportion of fibers gives better flexural strength from among the sample 1 and sample 2. Among this result sample 3 is highly better than the other two samples.

7. Discussions

7.1 Impact Test

The comparison graph for impact test for the all the specimens are given below in the fig. 9. From the impact test results the sample 3 which contains 35% of fiber and 65% of resin having more impact value than the sample 1 and sample 2. Because of high proportion of fiber gives good bonding strength to the sample 3 from among the sample 1 and sample 2.



Figure 9 Impact strength comparison for all samples

7.2 Tensile test

7.2.1 Load Vs displacement

The comparison graph for Load Vs Displacement for the all the specimens are given below in the fig.10. From the comparison graph between load Vs displacement, from among

the three samples, the sample 1 which contains 35% of fiber and 65% of resin having the better load



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carrying capacity than the other two samples. Because of high proportion of fiber gives better load carrying capacity to the sample 3 from among the sample 1 and sample 2.



Figure 10 Load and displacement comparison for all samples

7.2.2 Tensile Stress Vs Strain

The comparison graph for Stress Vs Strain for the all the specimens are given below in the fig. 11. From the comparison graph between stress Vs strain relationship and comparison values of tensile test results we know that the Peak load for sample 1 and sample 2 are 817.595 N and 1115.142 N respectively but for sample 3, peak load is 1179.702 N, at the same time Ultimate Tensile Strength for sample 1 and sample 2 are 20.964N/mm² and 28.596 N/mm² respectively but for sample 3 is 30.244 N/mm². Because of high proportion of fiber gives better load carrying capacity to the sample 3 from among the sample 1 and sample 2.





From these results I found that the Ultimate Tensile Strength and peak load of sample 3 is higher than the sample 1 and sample 2. So, from the results, the ratio of fiber and resin in sample 3 is the better ratio when compared with the other samples.

7.3 Flexural Strength Test

The results which are obtained by the Flexural Strength are given in the fig.12. This test is conducted on all the samples 1, 2 & 3.From the test we found that the flexural strength for the sample 1 and sample 2 are 50.905 MPa, 56.571 MPa respectively and peak load for sample 1 sample 2 are 79.142 N and 88.251 respectively. Flexural strength and peak load for sample 1 are found as 75.990 MPa and 118.544 N which is comparatively higher than the sample 1 and sample 2. Because of high proportion of fibers gives better flexural strength from among the sample 1 and sample 2. Among this result sample 3 is highly better than the other two samples.



Figure 12 Flexural strength comparison for all samples

8. Summary

The incorporation of Sisal and Banana fibers in the ratio of 35% of fiber and 65% of resin in to the Epoxy matrix showed the moderate improvement in the tensile, impact and flexural strength properties of the composites. From the results of Impact, Tensile properties and Flexural Strength test report, it conclude that the sample 3 (35% fiber and 65% resin) composite material have the higher impact value, higher load carrying capacity, higher ultimate tensile strength and also having higher flexural strength which was obtained



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from the impact, flexural strength and tensile tests. So this ratio fiber performs well on mechanical characteristics better than other ratio of Fibers. The hybridization of these natural fibers has provided considerable improvement of tensile, impact and flexural strength when compared to individual reinforcement. This is mainly due to transfer of loads among the fibers and eventually it is evident that the material obtained from the compression moulding with banana and sisal fiber in the ratio of 35% of fiber and 65% of resin is the most suitable replacement in most of the modern equipment.

References

- [1] P.V. Josepha, K. Joseph, 'The thermal and crystallization studies of short sisal fiber reinforced polypropylene composites', 2011.
- [2] Kuruvilla Joseph and Sabu Thomast 'Effect of chemical treatment on the tensile properties of short sisal fiber-reinforced polyethylene composites' Polymer Vol. 37,2010.
- [3] K.John, S. Venkata Naidu, 'Sisal fiber/glass fiber hybrid composites: the impact and compressive properties', J. Rein. Plast, 2004, 1253–1258.
- [4] Anil N. Netravali and Shitij Chabba 'Composites get greener', Volume 8, April 2013.
- [5] Vijay Kumar Thakurab, A. S. Singhab 'Mechanical and Water Absorption Properties of Natural Fibers/Polymer Biocomposites', Polymer-Plastics Technology and Engineering pages 694-700, Volume 49, Issue 7, 2010.
- [6] A.Varada Rajulu, G. Babu Rao, L. Ganga Devi, D. Sidda Ramaiah, K. Shubhaprada, K. Shrikant Bhat, R. Shylashree, 'Mechanical properties of short, natural fiber hildegardia populifoliareinforced styrenated polyester composites', J. Rein. Plast Volume 29, 2010.