Experimental investigation of mechanical characteristics of natural resin reinforced glass/ banana fiber composite

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***Abstract*— The growing environmental concerns global warming, waste management issues, dwindling fossil resources and rising oil prices have resulted in increase for newer materials. That are friendly to our health and environment. Green products are being increasingly promoted for sustainable development. The present research is an attempt to develop and investigation of two different types of fibers like one is Glass fiber (Synthetic type) the next one is Banana fiber (Natural type) and Reinforced natural resin Vajram (Gum Arabic) as matrix material to make the six number of plates in different (Fiber: resin) mixing ratio using reinforced natural resin Glass / Banana fiber composites, with the help of hand layup and compression molding methods. Mechanical properties like Tensile strength, Flexural strength, Impact strength and hardness for reinforced natural resin Glass / Banana fiber composites have been investigated and compared. Further considerable increase the matrix material ratio composites has improved the mechanical properties. It has also been found that the plate number four (30(F):70(R)) with reinforcement resin mixture Vajram (Gum Arabic) 80% and Epoxy (20%) possess shows the highest Tensile strength, Flexural strength, Impact strength, and Hardness compare to other five plates.**

Keywords*— Reinforced natural resin; vajram (Gum Arabic); Hand layup; Compression molding; Resin mixing ratio

1.Introduction

An increased pressure from environmental activist, preservation of natural resources, and attended stringency of laws passed by developing countries leads to the invention and development of natural materials with focus on renewable raw materials [1].A Composite material consists of two or more chemically distinct constituents, on a macroscopic level, having a distinct interface separating them. One or more discontinuous phases therefore are embedded in a continuous phase to form a composite. The discontinuous phase is usually harder and stronger than the continuous phase and is called the reinforcement, whereas, the continuous phase is termed the matrix [2].For the past decade, various discipline and application were trying to replace the synthetic fibres with natural fibres as reinforcements in polymer composite. This is because natural fibres are biodegradable, cheap, lightweight and abundant when compared to synthetic fibres [3]. Composite industries have therefore looked for plant based natural fibre reinforcements such as flax, hemp, jute, sisal, kenaf and banana as alternative materials, which are going to replace the synthetic fibres. Natural fibre reinforced polymer composites have been used for many applications such as in automotive components, aerospace parts, sporting goods and construction industry because of the advantageous properties of these materials [2,4].

Vajram (Gum Arabic) also called as Acacia gum can be a natural gum prepared of hardened sap taken from acacia tree’ s two species such as Acacia Senegal and Acacia Seyal. It can be a compound mixture of glycoproteins and polysaccharides, employed mainly in industry of food as preservative[5].

In the early of 1970 the common technique of pasting specimens to sheet with glue (usually Gum Arabic or locally called as Vajram in local Andhra markets). The glue paste is made by adding flakes of glue to boiling water, gradually and in small quantities, till it makes a thin paste. As the paste become thick and hard on cooling, the vessel containing glue should be kept on low heat during the mounting work. Small quantity of mercuric chloride or thymol crystals or copper sulphate may be added to the glue as insect repellent [6].

The name "Gum Arabic" was derived from the fact that it was shipped to Europe from Arabian Ports in the old years. Acacia gum can be organized from an exudates from the stems and Acacia seyal (Leguminosae) and Acacia senegal trees branches and generated obviously as large nodules during a procedure known as gummosis to closed injury in the tree' s bark. This type of gum is quite nontoxic and can be in utilizing from very old years. There is a current appraisal of this and other exudates gums [7].

The Gum arabic contains mixture of lower molecular weight polysaccharide such as $\sim 0.25 \times 10^6$ Da, major component and superior molecular weight hydroxyproline-rich glycoprotein such as $\sim 2.5 \times 10^6$ Oa; minor component. When it is a mixture and the material differs considerably with source, the accurate molecular structures can be still rather indecisive [8].

The husk that passing through a maximum 4mm sieve aperture was blended with an adhesive liquid resin of gum Arabic to form Fonio Husk Particleboard (FHP) samples. The resin binder was a product of crushed balls of gum Arabic that was mixed with water at ratio 4:3 by weight. The resin was introduced at percentage levels of 20%, 25%, 30%, 35%, 40% and 45% by weight. After pressing, heat treatments and curing, the particleboard samples were tested for mechanical strengths. The compressive strength ranged from 0.057N/mm2 at the 20% level to 0.369N/mm2 at the 45% level. Tensile strength increased steadily with an increase in resin levels peaking at 0.792 N/mm2 for 45% level. The flexural strength followed the same trend peaking at 45% level with 3.697 N/mm2. Some of the values met the minimum values prescribed by British, American and European Standards. The boards may not be used as load bearing materials, but will be better suited as internal wall partitions and ceiling materials [9].

As a matrix material, vajram [Gum Arabic] is widely used because it has some excellent characters for composite fabrication. Vajram is also very suitable for filling, reinforcing and blending. Some of the mechanical and physical properties of Vajram [Gum Arabic] are tabulated in Table 1.

Synthetic fibers are made from synthesized polymer. In present time Glass fibers are commonly used fiber for various polymer composites. It offers various advantages like high strength, chemical resistant, good insulation, and elasticity. There are various types of glass fibers like A glass, S glass, E glass, D glass etc. Among these types E glass and S glass are commonly used due to their High tensile strength. Commercially available Glass fibers are in the form of woven cloth, chopped fibers and long continuous fibers. E-glass fiber is mainly used where cost of development is restricted as in household products like glass fiber doors, window frames and sports products etc. when strength to the component is more important than the cost in that case S glass fibers are used. Components made of S glass fibers are used in ship hull, tail wings of airplane, vessels, vehicle components etc. Some of the mechanical and physical properties of Glass fiber are tabulated in Table 2 [10].

Natural fibres are cellulosic materials; they consist of micro fibrils in an amorphous matrix of lignin and hemicellulose. These fibres consist of several fibrils that run all along the length of the fibre. The hydrogen bonds and other linkage provide the necessary strength and stiffness to the fibres. Natural fibres are grouped into three types: seed hair, bast fibres and leaf fibres depending on its source. Some examples are cotton (seed hairs), ramie, jute and flax (bast fibres), sisal and banana (leaf fibres) [11].

In a tropical country, fibrous plants are available in abundance and some of them like banana are agricultural crops [12].

Banana bast fibre is a waste product of banana plant cultivation. It is a lingo-cellulosic fibre, which can be extracted from the pseudo-stem of banana plant with better mechanical properties [13]. Banana fibre possesses good specific strength properties comparable to those of conventional materials, like glass fibre [14]. Some of the mechanical and physical properties of banana fibre are presented in Table 3 [15].

The composites were manufactured at various ratios such as 30:70, 35:65, and 40:60 (Fiber: Resin). We also come to know that increase in fiber content increases mechanical properties but increases brittleness and start delaminating. The material with 50:50 compositions is good for application as it has optimum properties with less brittleness [16].

The present research is an attempt to develop and investigation of two different types of fibers like one is Glass fiber (Synthetic type) the next one is Banana fiber (Natural type) and Reinforced natural resin Vajram (Gum Arabic) as matrix material to make the six number of plates in different (Fiber: resin) mixing ratio using reinforced natural resin Glass / Banana fiber composites, with the help of hand layup and compression molding methods. Mechanical properties like Tensile strength, Flexural strength, Impact strength and hardness for reinforced natural resin Glass / Banana fiber composites have been investigated and compared.

2.Experimental procedure

2.1. Materials

In this study Glass and Banana fibers have been used along with Natural resin reinforced Vajram [Gum Arabic] and araldite AW106 epoxy resin as matrix material.

2.2. Matrix material preparation

Vajram [Gum Arabic] was sourced from local markets. The Epoxy was sourced from Covai Seenu& company, Coimbatore.

First, to the prepare for Vajram [Gum Arabic] resin. It is initially solid-state material to mixing of water with [80:20] percentage of mixing. After the 20 hours to take and curling the resin water mixture to form the Liquid state.

After to add the Epoxy resin for Reinforcement. It is the important process to increasing the strength of Vajram [Gum Arabic]. The different ratios of mixing Liquid state of Vajram [Gum Arabic] and Epoxy resin is [85:15] & [80:20] are prepared for natural resin reinforced.

2.3. Fibers preparation

Glass fibers were obtained from the Covai Seenu &company, Coimbatore, Tamil Nadu, India. The E-type Glass fiber [400 GSM] standard.

Banana fibers were obtained from Parimalam Fibers, Erode, Tamil Nadu, India. The Banana mat type fiber. The fibers plate configuration was prepared by arranging and cutting for [28×25] centimeter’ s for cloth based.

2.4. Fabrication of Plates

A thin layer of wax was applied on the surface of the mold in order to ensure composite will be easily removed, the plates fabricated for the Hand Lay-Up method. The plate dimension is [28×25] centimeters at the thickness is 6-8 millimeters. To taking the resin and fiber mixing in weight ratio method asper the percentage of mixing ratio in Fiber and Resin. The six number of plates to fabricate in different [Fiber:Resin] mixing ratio.

The outcomes of fabrication six number of plates by Hand Lay of method Dispersion of Resin was not uniform thought, Improper surface of the Composite, Bonding between lamina was not uniform, Air ingress during cure of composite. To overcome this causes its to putting the compression molding is apply the load in 1500 psi in fabricated plates to increasing the dispersion of Resin was not uniform, the fabricated plates to applied in the heat in 85ºc in 2 hours in oven its increased the strength of plate and Bonding between lamina was uniform. In these processes to overcome the causes of Hand Lay of methods.

2.5. Description of the Plates

Table 2.1.1: E-GF(25%) + Resin (75%) + vajram (85%)+ Epoxy(15%) plate

PLATE 1	FIBERRES IN MIXING RATIO	FIBER	RESIN	RESIN MIXING RATIO	VAJRAM [Gum Arabic]	EPOXY
		25%	75%		85%	15%
FIBER TYPE	Glass Fiber [400 GSM]			VAJRAM MIXING RATIO	VAJRAM [Gum Arabic]	WATER
					80%	20%
NO. OF LAMINAS	15 Laminas			TIMEFOR CURING	21 Days	

Table 2.1.2: E-GF(25%) + Resin (75%) + vajram (80%)+ Epoxy(20%) plate

PLATE 1	FIBERRES IN MIXING RATIO	FIBER	RESIN	RESIN MIXING RATIO	VAJRAM [Gum Arabic]	EPOXY
		25%	75%		80%	20%
FIBER TYPE	Glass Fiber [400 GSM]			VAJRAM MIXING RATIO	VAJRAM [Gum Arabic]	WATER
					80%	20%
NO. OF LAMINAS	15 Laminas			TIMEFOR CURING	21 Days	

Table 2.1.3: E-GF(30%) + Resin (70%) + vajram (85%)+ Epoxy(15%) plate

PLATE 1	FIBERR	FIBER	RESIN	RESIN MIXING	VAJRAM [Gum Arabic]	EPOXY

	ESIN MIXING RATIO	30%	70%	RATIO	85%	15%
FIBER TYPE	Glass Fiber [400 GSM]			VAJRAM MIXING RATIO	VAJRAM [Gum Arabic]	WATER
					80%	20%
NO. OF LAMINAS	15 Laminas			TIMEFOR CURING	21 Days	

Table 2.1.4: E-GF(25%) + Resin (75%) + vajram (85%)+ Epoxy(15%) plate

PLATE 1	FIBERRESIN MIXING RATIO	FIBER	RESIN	RESIN MIXING RATIO	VAJRAM [Gum Arabic]	EPOXY
		30%	70%		80%	20%
FIBER TYPE	Glass Fiber [400 GSM]			VAJRAM MIXING RATIO	VAJRAM [Gum Arabic]	WATER
					80%	20%
NO. OF LAMINAS	15 Laminas			TIMEFOR CURING	21 Days	

Table 2.1.5: E-BF(25%) + Resin (75%) + vajram (85%)+ Epoxy(15%) plate

PLATE 1	FIBERRESIN MIXING RATIO	FIBER	RESIN	RESIN MIXING RATIO	VAJRAM [Gum Arabic]	EPOXY
		25%	75%		85%	15%
FIBER TYPE	Banana Fiber			VAJRAM MIXING RATIO	VAJRAM [Gum Arabic]	WATER
					80%	20%
NO. OF LAMINAS	15 Laminas			TIMEFOR CURING	21 Days	

Table 2.1.6: E-BF(30%) + Resin (70%) + vajram (80%)+ Epoxy(20%) plate

PLATE 1	FIBERRESIN MIXING RATIO	FIBER	RESIN	RESIN MIXING RATIO	VAJRAM [Gum Arabic]	EPOXY
		30%	70%		80%	20%
FIBER TYPE	Banana Fiber			VAJRAM MIXING RATIO	VAJRAM [Gum Arabic]	WATER
					80%	20%
NO. OF LAMINAS	15 Laminas			TIMEFOR CURING	21 Days	

Plate 1

Plate 2

Plate 3

Plate 4

Plate 5

Plate 6

Fig 1: E-GF(25%)+Resin (75%)+ vajram (85%)+ Epoxy(15%) plate

Fig 2:E-GF(25%) + Resin (75%) + vajram (85%)+ Epoxy(15%) plate

3. Mechanical characterization

3.1. Tensile test

The tensile test was performed in accordance with the MME4 Tensile (FRB) – ASTM D638-03 standard. The test specimen size was 165 mm x 19 mm x 6 mm. The test was performed on universal testing machine (U.T.M) of 10- tonne capacity. The flat specimens of required size were fixed between the grips of each head of the testing machine in such a way that the direction of force applied to the specimen is coincident with the longitudinal axis of the specimen.

3.2. Flexural test

Three-point bend test was performed as per the MME5 Flexural (FRB) ASTM D790-02 standard. The test specimen was 100 mm x 112.7 mm x 6 mm. The test was performed on universal testing machine. Two parallel roller supports were used to support the specimen and load was given by means of loading nose midway between the supports.

3.3. Impact strength

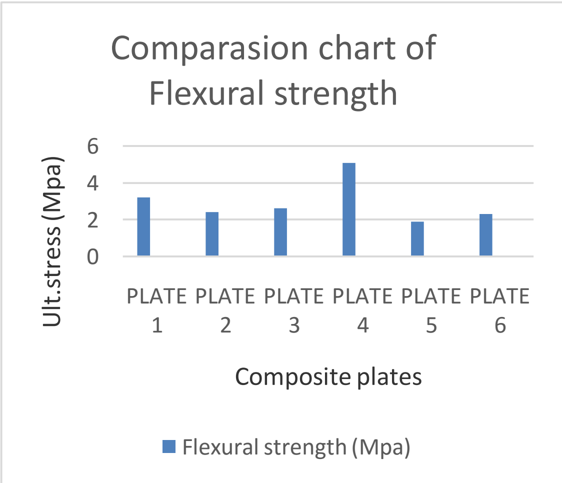
Charpy impact strength specimens were prepared as per the MME8 imapact test (FRB) – ASTM D256-10 ASTM standards. The test specimen of 65.5 mm x 10.2 mm x 6 mmwas prepared and V notch was provided using the triangular file of 2mm. The specimen was fixed in the vice of the testing machine. When the pendulum was released with the help of operating lever, then the amount of energy absorbed by the material was observed and the impact strength was calculated.

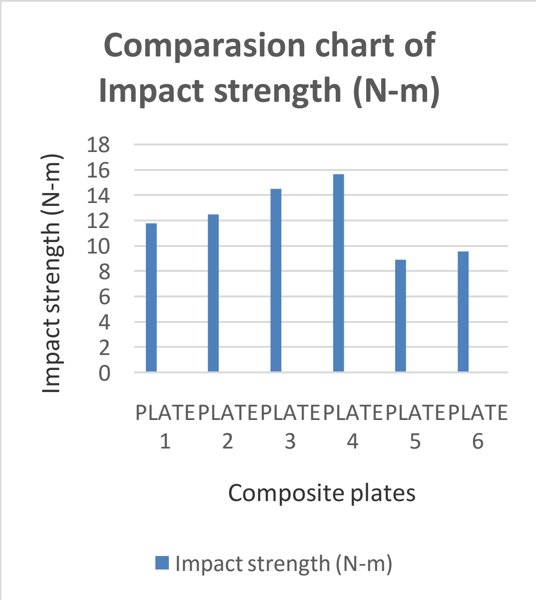
3.4. Hardness strength

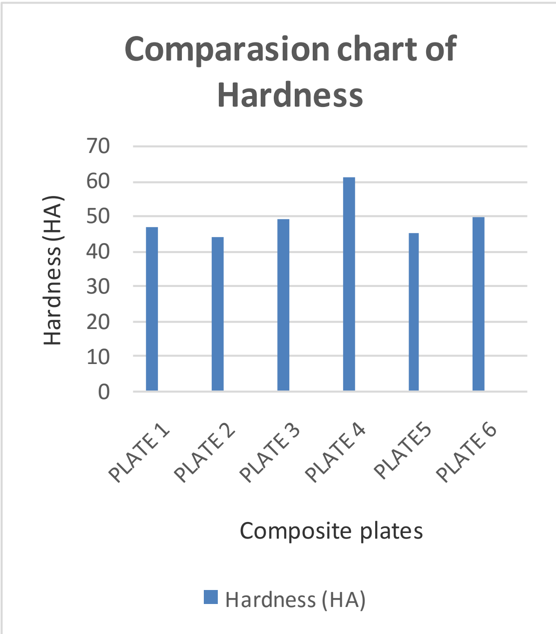
Shore “ D” hardness test specimens were prepared as per the MME18 Micro, Hardness – ASTM E407 standard. The test specimen size was 15mm×15mm. the specimen was set to the flat table, the indenter used for shores D type. The hardness test measures the depth of an indentation in the material created by given force on a standardized presser foot.This depth dependent on the hardness of the material its viscoelastic properties, the shape of the presser foot, and duration of the test. Configuration of Type “ D” carbide ball 30°cone, diameter 1.40mm, Extension 2.54mm, spring force 44.48N. The portable Dynamic hardness tester used to measuring the Hardness.

4. Result and Discussion

The different types of (Fiber: Resin) mixing ratio fabricating six number of plates using natural resin reinforced in Glass/ Banana fiber based composites. Various characterization tests were conducted and their results are depicted in the table







4.1. Tensile strength

It was observed that the tensile strength of plate number four composites showed better results as compared to the other five composites. In general tensile strength of epoxy was 30-35 N/mm2, but the tensile strength of plate number four composites with 70% resin fraction shows the significant increase in the tensile strength with the maximum value of MPa. It directly indicates the positive effect of reinforcement in the material. Fig 3ashows the comparison of tensile strength of natural reinforced fiber composites.

4.2. Flexural strength

Three-point bending test was conducted on UTM and observed that the flexural strength of plate number four natural resin reinforced based composite shows better flexural strength as compared to other five composites. There was increase in strength of the composites is increasing the resin mixing ratio in composites Fig 3b shows the comparison of flexural strength of natural reinforced composites fiber composites.

4.3. Impact strength

Charpy test was conducted on Impact testing machine and observed that the impact strength of plate number four composite shows better impact strength as compared to other five composites. These was a increasing the reinforced natural resin ratio in compositesfibers. Fig 4 shows the comparison in impact strength of composites with and without surface treatment.

4.4. Hardness test

Shore " D" hardness test was conducted on Dynamic hardness tester, the indenter used for shores D type. The hardness test measures the depth of an indentation in the material created by given force on a standardized presser foot. The tester observed the hardness strength of plate number four composites shows better hardness strength as compared to other five composites. Fig 5 shows the comparison of Hardness strength of natural reinforced composites fiber composites.

5.Conclusion

The project runs around bringing in the utilization of Natural fibre and Resins which is bio degradable. Here a Natural fibre and Resin composites providing best properties and easy availability is been selected. Due to the longer time of curing in the absence of catalyst and completely soluble nature of vajram, and combinations of mixture of vajram, Epoxy are prepared. Composites with such combinations were initially fabricated with Hand Lay-Up method on trial and error basis to study the bonding ability of Resin with Fiber and curing nature. It is found the combination vajram and Epoxy resulted out as a better combination comparatively.

To overcome the disadvantages of Hand Lay – Up method, Compression molding is used. six plates were fabricated and their Tensile, flexural, Impact strength were studied. It is found that Plate number 4 [30%(F):70%(R)] with larger percentage of vajram (80%) and Epoxy 20% possess relatively high

Tensile, flexural Impact Strength& Hardness strength.

6.References

1. N. Amira,*, Kamal Ariff Zainal, et al (2017) **" Effects of Fibre Configuration on Mechanical Properties of Banana Fibre/PP/MAPP Natural Fibre Reinforced Polymer Composite**"

2. M R Sanjay*, B Yogesha, et al (2017) **" Studies on Natural/Glass Fiber Reinforced Polymer Hybrid Composites: An Evolution"**

3. D.N. Saheb, J.P. Jog, et al (1999**). " Natural fibre polymer composites: a review. Advances in polymer technology,"** 18(4), 351-363.

4. M Rajesh, Jeyaraj Pitchaimani, N Rajini, et al (2016) **" Free Vibration Characteristics of Banana/Sisal Natural Fibres Reinforced Hybrid Polymer"** Composite Beam. Procedia Enginering, 144, 1055-1059.

5. Ugoamadi, C. C. et al (2013) picked cashew nuts and processed for the extraction of the resin content.

6. Muyiwa Turoti and Samson Kikiowo et al (2015) presented and discussed gum Arabic polymers

7.Ndububa E. et al (2015) et alfocused on Fonio (" Acha") husk

8.Q.T. Shubhra, A.KM.M. Alam, & M.A. Quaiyyum. et al (2011). **" Mechanical properties of polypropylene composites: A review. Journal of Thermoplastic Composite Materials,"** 0892705711428659.

9.Rahul Shrivastavaa, Amit Telangb, et al (2017) **" Mechanical Properties of Coir/ G Lass Fiber Epoxy Resin Hybrid Composite"**

10. Muhammad Khusairy Bin Bakria, et al (2017) " Processing and Characterization of Banana Fiber/Epoxy Composites: Effect of Alkaline Treatment"

11. M. Mariatti, M Jannah, A. Abu Bakar., & H.PS. Abdul Khalil et al(2008). **" Properties of banana and pandanus woven fabric reinforced unsaturated polyester composites."** Journal of composite materials, 42(9), 931-941.

12. V.S. Srinivasan, S. Rajendra Boopathy, D. Sangeetha, B. Vijaya Ramnath. et al(2014**). " Evaluation of mechanical and thermal properties of banana–flax based natural fibre composite."** Materials & Design, 60, 620-627.

13.L. Herrera-Estrada, S. Pillay, U. Vaidya, et al (2008). **" Banana Fibre Composites For Automotive and Transportation Applications."** In 8th AnnualAutomotive Composites Conference and Exhibition (ACCE) (pp. 1618).

14. Vishnu Prasad, Ajil Joy, G. Venkatachalam, S.Narayanan, S.Rajakumar et al(2014) **" Finite Element analysis of jute and banana fibre reinforced hybrid polymer matrix composite and optimization of design parameters using ANOVA technique."** Procedia Engineering, 97, 1116-1125.

15. M. Ramesh, T.Sri Ananda Atreya, U. S. Aswin, H. Eashwar, C. Deepa et al (2014**) " Processing and Mechanical Property Evaluation of Banana Fibre Reinforced Polymer Composites."** Procedia Engineering, 97, 563-572.

16. P.J Herrera-Franco, A Valadez-González, et al (2004) **" Mechanical properties of continuous natural fibre-reinforced polymer composites, Composites"** Part A: Applied Science and Manufacturing, 35(3), 339-345

17.M.R. Bambach, et al (2017**) " Compression strength of natural fibre composite plates and sections of flax, jute and hemp"**