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COMPARING THE FABRICATION AND PERFORMANCE ASSESSMENT OF FIBRE REINFORCED CASHEWNUT SHELL RESIN BIOCOMPOSITES

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Abstract

Land, and water bodies are affected by plastic materials. Due to its non biodegradability more percentage of marine and land creatures have died. For 258 million tons only 35% of plastic materials was recycled out of 63% of solid waste which was generated in U.S on 2014.So we need to find an alternative method by implementing biochemical material for food packaging applications that could eventually decompose the plastic materials. So we planned to prepare a bio composite material which has a matrix phase and fibre phase which are of biochemical and natural compounds. The bio composite material consist of cashew nut shell liquid (CNSL) as a matrix phase and bamboo, groundnut, saw dust, tamarind are added as a reinforcement material. After preparing the bio composite material we have to conduct various tests for checking its properties. So various tests like tensile test, flexural strength of the material, impact test, water absorption test, biodegradability test are conducted for our bio composite materials to check its properties. From the experimental results we compared which bio composite material is more suitable for food packaging applications and the test results are mentioned below.

Keywords: Natural fibres, Cashewnut shell resin, Mechanical properties, Epoxy.

1.Introduction

Nowadays, Natural fibers as a reinforcement has recently attracted the attention of researchers in the field of material sciences. Because they are environmental friendly, biodegradable, abundantly available, cheap and low density. Plant fibers such as jute, hemp, cotton, flax, ramie, manila, abaca, sisal, Pineapple,bagasse are observed to be light compare to the glass, carbon and aramid fiber. Natural fibers are generally lignocellulosic in nature, consisting of material with the minimum of two or more distinct constituents or phases that have different physical or chemical properties, which are constructed into a complex architecture at micro-, meso- or macro-scale levels. The development of composite materials has enriched modern material systems, contributed to sustainable advances in materials science engineering and improved the human life. Composite materials generally have higher strength- and modulus-to-weight ratio than traditional material. This material can reduce the weight of a system by as much as 25 to 35%. So the weight savings of the material will directly enhance the energy savings and also help to increase the performance. Dendrocalmus strictus exhibits 53% of total bamboo area in India. These plants can grow upto an height of 1000 m in semi dry and dry zone in plain and hilly areas. It is widely adaptable to temperature as low as -5°C and as high as 45°C.It occurs naturally in tracts receiving as low as 750 mm of rainfall and also in extensive gregarious patches. The internodes are 30-45 cm long, aerial stems are 8-16 m high,25-80 mm in diameter pale blue green when young, dull green or yellow on maturity, much curved above half of its height , basal nodes often rooting, lower nodes often with branches.. Tamarind is a member of dicotyle-donus family fabaceae. The tamarind tree is long lived, large evergreen or semi green tree, grows wild though cultivated in 2 limited extent. A mature tree may attain a height of 30 m. It has nitrogen fixing capability so it can grow in poor soils and it can withstand long period of drought makes them ideal low input ,high yielding trees. The fruit contains about 55% pulp, 34% seed, and 11% shell and the fiber in a pod. The fruit is pendulus, the pods are oblong or sausage shaped, curved or straight with rounded ends. The shell is light greenish often irregularly constricted between seeds, brittle, and easily broken if pressed. The pulp is blackish-brown in colour and the pulp is thick. During woodworking operations such as sawing, sanding, milling, planning, and routing the by products obtained are saw dust. Small chippings of wood are present in saw dust. Woodworking machinery, portable power tools or hand tools are used in this wood working operations. Certain animals, birds and insects which live in wood such as woodpecker and carpenter ant produces the by product like wood dust. In some manufacturing industries they are used as a source of occupational health hazard and it is significant fire hazard. Groundnut is a nutritious leguminous crop, grown mainly for seed and oil world wide. After the removal of groundnut seed from its pod, groundnut shells are the leftover product obtained. Under natural condition it has very slow degradation rate and it is a abundant agro waste industrial product. However ground nut shells contains various bioactive and functional components which are beneficial for mankind. Commercially it is used as a feedstock, filler in fertilizer and even in bio-filter carriers. Burnt or buried groundnut shell results in environmental pollution. Thus new technology need to be developed in order to obtain zero waste production.

2. Materials and Methodology

2.1 Materials

The Cashewnut shell resin was collected from Plaza Chemcial Industries, Coimbatore district. This raw material is used as the matrix phase in our study and fibres are collected locally as they are by-products of other process. Epoxy resin (LY556) with th density of 1100-1400 kg/m3 and hardener (HY951) was purchased from Heranba Instruments & Engineers,Chennai. In order to make a composite material the matrix phase of epoxy resin should be converted to a hard material by using cross-linking agent to make a composite material. The resin and hardener xx may have a different densities, so the mix ratio by the weight could be very different than the mix ratio by volume. For best results when mixing and measuring by hand,choose a 10:1 mix ratio of epoxy/hardener.

Colour	Brownish red colour
Odour	Cashew odour
Flammability	Not flammable
Viscosity	(at 303 K) 200 cP
Specific gravity	(at 303K) 0.95 g/cm^3
Toxicity	Non-Toxic

Table 1 Properties of cashew nut shell resin

2.2. EXTRACTION OF BAMBOO FIBRE

The bamboo is collected from the local market. Then it is stripped into sheds and for better handling and easy extraction of fibre in the required structure. Then the fibre in dipped in 10% conc. NaOH solution for about 2 days. This helps in extracting fibre and it enhances the reinforcement of fibre with matrix. After 2 days the fiber dipped in NaOH solution is washed with distilled water to remove excess NaOH present. Then the bamboo is kept for drying. The dried bamboo is the fibre which we use to reinforce with matrix.

2.2.1. Powdering of Tamarind Seed

The tamarind seeds are collected from local market. Then the tamarind seeds are needed to be powdered for uniformity and by using powder we could easily extract the chemical properties for tamarind seed which helps in binding with matrix. The tamarind seed is powdered using bur mill. The powdered feed has no uniformity in size so it is sieved in an sieve analysis, then the fine product which is from bottom pan is taken for the preparation of bio composite then there is no need of preliminary treatment for tamarind seed powder it can be directly used to prepare composite. The groundnut shell are collected as waste in agro industry and we are using it as a fibre by mechanical crushing. The saw dust are available easily which can be collected from construction sector and it used as a fibre/cellulosic material. So implementing the groundnut and saw dust fibre/cellulosic material into matrix phase is very easy and no further treatment is necessary.

2.2.2. COMPOSITE AND MOULD FABRICATION

The Galavanized Iron sheet(G.I.sheet) was purchased near Perundurai and that should be cutted with the dimension of around 20 cmx 20 cm x2 cm and they were folded and welded to make a mould without any leakage to prepare the composite materials. To avoid such leakages we must perform full penetration weld process. Before using the mould the it should be cleaned with the help of a dry cloth and proper lubricant must be applied for easy removal of the material after they cured. Here we use grease as the lubricant for the mould. Epoxy resin and hardener must be taken up in the ratio of 10:1 in all four composites. We took 3 grams of each fibres namely Bamboo fibres, Groundnut shell, Saw dust and Tamarind powder. And we are adding 3 gram of fibres with 30 ml of Cashew nut shell resin oil with epoxy resin as a binding agent and they are stirred for about 10 minutes. Then the mixture is poured up in the mould which is lubricated with grease by Hand-lay up technique. Here the matrix phase is Cashew nut shell resin and the reinforcing phase are the four fibres which we use. Then the mould is kept for curing for about 10-12 hours under sunlight to form a composite material.

Fibres	Weight of fibres (g)	Matrix (CNSL) (ml)
Bamboo	3	30
Saw dust	3	30
Groundnut	3	30
Tamarind seed	3	30

Table 2. composition of Bio-Composite material-1

Fibres	Weight of fibres (g)	Matrix (CNSL) (ml)
Bamboo	5.7	27.1
Saw dust	5.7	27.1
Groundnut	5.7	27.1
Tamarind seed	5.7	27.1

Table 3. composition of Bio-Composite material-2

3.Mechanical properties of BioComposites

3.1. Impact Strength

For measuring the impact strength, we are using IZOD-CHARPY IMPACT TESTER D256 it is a single point test that measures resistance to the impact from a swinging pendulum. The IZOD impact defines as kinetic energy needed to initiate and continue to fracture until the specimen is get broken. As per the ASTM D 256 ISO 180 the standard dimension for specimen is around 5cm x 1.3 cm x 0.3 cm. The specimen should have a thickness of around 0.3 cm exactly because the specimen should be perfectly fit the notch of the impact tester. After the specimen cuts with a specific standard dimension, they should clamp into the pendulum impact test fixture with the notched side facing the striking edge of a pendulum. By pressing the load button the pendulum attached with the impact tester will be released and allowed to hit on the specimen surface. As per the IZOD impact tester, they calculate the amount of workdone in Joule. The Impact strength was expressed at the unit of J/m.

BIOCOMPOSITE MATERIALS	**IMPACT VELOCITY**	**WORK DONE (J)**
Bamboo	3.457	0.508
Tamarind seed	3.457	0.379
Saw dust	3.457	0.294
Groundnut shell	3.457	0.209

Table 4. Impact strength of Bio-Composite material-1

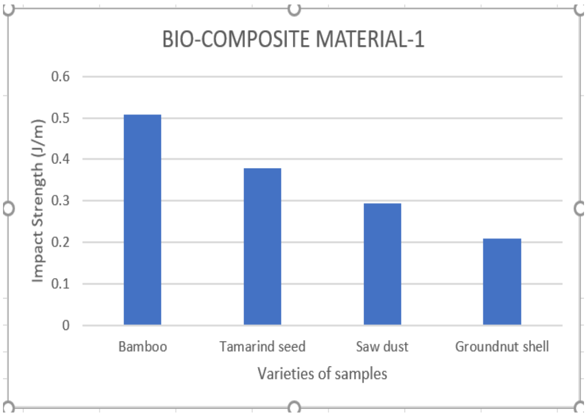

Figure 1. Impact strength of Bio-composite material-1

BIOCOMPOSITE MATERIALS	IMPACT VELOCITY	WORK DONE (J)
Bamboo	3.457	1.805
Tamarind seed	3.457	1.851
Saw dust	3.457	0.337
Groundnut shell	3.457	7.975

Table 5. Impact strength of Bio-Composite material-2

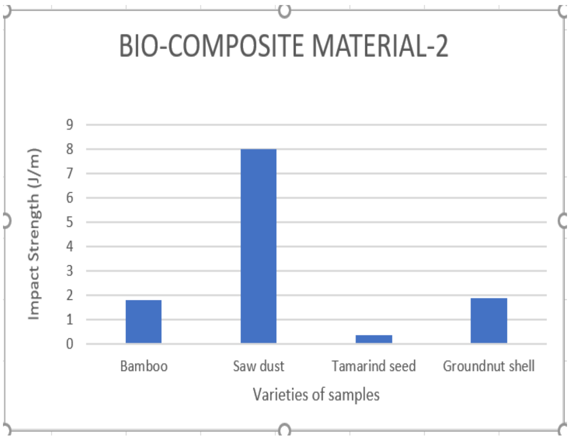

Figure 2. Impact strength of Bio-composite material-2.

By Comparing the Bio-composites bamboo has high work done (hence the work denotes the amount of energy applied to broke the specimen) in Bio-Composite Material-1 and Saw dust in Bio-Composite Material-2.The velocity is kept constant for all composites that is impact velocity of 3.457 m/s. The least work is done for Groundnut in Bio-Composite Material-1 and Tamarind in Bio-Composite Material-2.

3.2. Flexural Strength

Flexural strength is used to measure the maximum forces that can withstand before it breaks. Here to measure the flexural strength of all four composites material we are using UNIVERSAL TESTING MACHINE. The specimen should be cut with the standard dimension of around 5cm x 2 cm x 0.5 cm and that was kept on the support span and the load is applied at the center of specimen by the loading nose. They produce a three-point bending at the specific rate. The result that was obtained from this test is consisting of Force (N), Elongation (mm), Flexural modulus at 1% strain, and flexural strength.

BIOCOMPOSITE MATERIAL	BREAK LOAD POINT (N)
Bamboo	9.8
Tamarind seed	7.4
Sawdust	1.7
Groundnut shell	6.2

Table 6.Flexural strength of Bio-Composite material-1

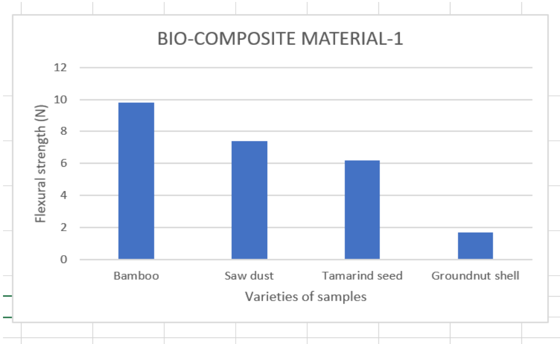

Figure 3.Flexural strength of Bio-composite material-1.

BIOCOMPOSITE MATERIAL	BREAK LOAD POINT (N)
Bamboo	11
Tamarind seed	7.9
Sawdust	10.3
Groundnut shell	16.3

Table 7.Flexural strength of Bio-Composite material-2

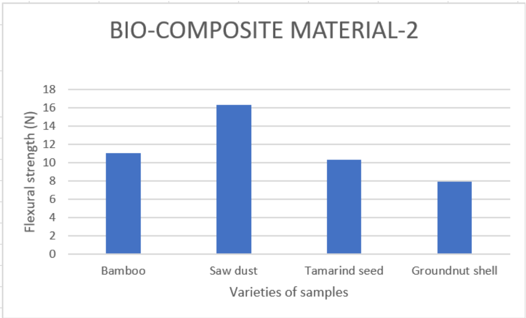

Figure 4.Flexural strength of Bio-composite material-2.

To analyse the composite material which can resist the deformation under the load can be examined by three-point bending mode using UNIVERSAL TESTING MACHINE (UTM). From the graph between Load (Kgf) Vs Deflection (mm). We noted that bamboo needs high load while compared to other composites in Bio-Composite Material-1 and Saw dust in Bio-Composite Material-2.

3.3. Tensile Strength

For testing tensile strength, we use UNIVERSAL TESTING MACHINE. Tensile strength can be defined as the maximum load that a material can withstand before breakage. The dimension of material used for this test is 16 cm x 1.3 cm x 0.3 cm. The material returns either partially or completely to its original shape and size when its stress less than tensile strength. The maximum limit of elastic behavior and the beginning of plastic behavior is indicated by yield point on a stressstrain curve. Below the yield point a material will deform elastically and will return to its original shape when the applied stress is removed. After reaching yield point the material reaches to its breaking point the point at which the degree of tension increases and material tends to break.

BIOCOMPOSITE MATERIAL	TENSILE STRENGTH AT YIELD POINT (Kg/cm^2)	TENSILE STRENGTH AT BREAK POINT (Kg/cm^2)
Bamboo	44.3	21.31
Tamarind seed	4.87	19.23
Sawdust	12.31	19.23
Groundnut shell	3.33	1.33

Table 8.Tensile strength of Bio-Composite material-1

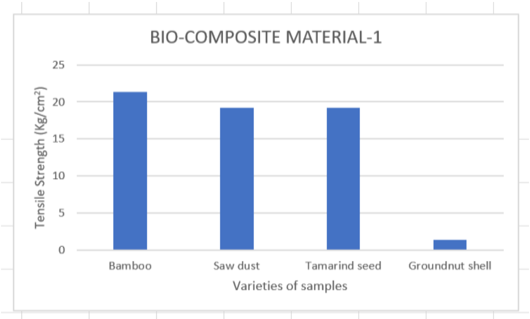

Figure 5.Tensile strength of Bio-composite material-1.

BIOCOMPOSITE MATERIAL	**TENSILE STRENGTH AT YIELD POINT (Kg/cm^2)**	**TENSILE STRENGTH AT BREAK POINT (Kg/cm^2)**
Bamboo	0.407	0.713
Tamarind seed	0.203	0.305
Sawdust	0.407	0.407
Groundnut shell	0.407	0.611

Table 9.Tensile strength of Bio-Composite material-2

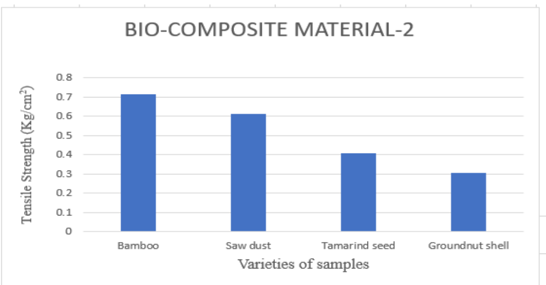

Figure 6.Tensile strength of Bio-composite material-2.

This test was conducted to analyze the stretch-ability or elasticity of the composite to withstand elongation of two slits. This property measures the Yield point and Break point of the composite materials under given load. The tensile test was done by UNIVERSAL TESTING MACHINE. Comparing the results we come to the conclusion that the bamboo composite has high tensile strength where as the groundnut has low tensile strength in the Bio-composite Material-1 and also for the Bio-composite Material-2.

3.4. Water Absorbtion

They used to determine the amount of water content that was absorbed by the specimen under the specific condition. This method gives the amount of moisture content absorbed by the composite material at the given condition. Generally the condition will be the room temperature and the pressure would be of 1 atm. Initially the composite material with the dimension of around 6.5cm x 6.5cm x 0.5cm was dried in an oven by keeping the temperature around 45^{0}c for about 10 minutes. After completion of drying process the specimen should be initially weighted and reading was noted down. Then the composite material was completely immersed in the beaker containing of 400ml of water for about 24 hour and note the weight of the specimen. Before weighting the composite material they must be completely dried with a lint of free cloth.

BIOCOMPOSITE MATERIALS	INITIAL WEIGHT(g)	FINAL WEIGHT(g)
Bamboo	3.05	3.74
Tamarind seed	3.07	3.36
Sawdust	3.14	4.2
Groundnut shell	3.05	3.32

Table 10.Water Absorbtion of Bio-Composite material-1

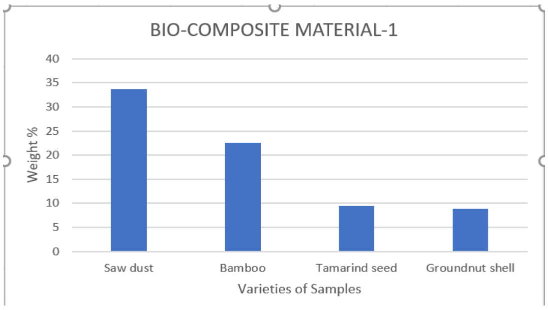

Figure 7.Water Absorbtion of Bio-composite material-1.

BIOCOMPOSITE MATERIALS	INITIAL WEIGHT(g)	FINAL WEIGHT(g)
Bamboo	3.1	3.9
Tamarind seed	3.08	3.5
Sawdust	3.00	4.8
Groundnut shell	3.12	3.45

Table 11.Water Absorbtion of Bio-Composite material-2

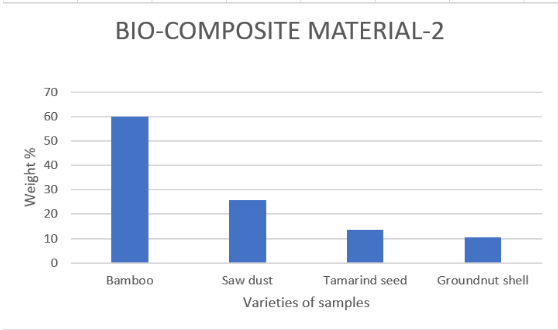

Figure 8.Water Absorbtion of Bio-composite material-2

The water uptake of the biocomposites are taken up and is plotted against soaking time of 24 hours. The result from the Fig 7, indicates that the saw dust has more affinity towards water where as the ground nut has less affinity towards water in the Biocomposite Material-1. From the fig 8, Bamboo absorbs high moisture content rather than other composites in the Biocomposite Material-2.

4. Conclusion

Based on this study of mechanical properties of different fibres, the tensile strength of bamboo is higher than other fibres whereas groundnut exhibits less tensile than other composites in both material 1 and material 2 . By comparison of flexural strength bamboo fibre composite exhibits high flexural strength in material 1 and in material 2 saw dust possess high flexural strength rather than other fibres and ground nut has least flexural strength for the material 1 and in material 2. By comparison of impact test here too bamboo has high impact strength in material 1 and in material 2 saw dust possess high impact strength while ground nut shell has less impact strength both in material 1 and 2. By water absorption we could see saw dust absorbs much amount of moisture/water than other fibres in material 1 and in material 2 bamboo absorbs much amount of moisture whereas ground nut composite absorbs less water. From water absorption test we could conclude that groundnut powder composite in less affinity for water. From each test results we could see the bamboo composite had performed well and it could even alter the saw dust composite. Bamboo shows good performance in mechanical testing but it absorbs water much more in material 2 and in material 1 saw dust absorbs more moisture content. Bio composites derived from ground nut shell and tamarind fails to compete with bamboo and saw dust. So these both composites are not preferred for applications such as containers in food packaging, in automobile using mudguard and in using circuit boards. Bio composites which is derived from bamboo and saw dust can be used as a containers in food packaging industries. Hence Bamboo and saw dust powder bio composite can be used rather than groundnut shell and tamarind composites.

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