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Natural Fiber Reinforced Composite in Energy Absorption Structures

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ABSTRACT : *Composite materials along with the thermoplastic matrices and with the reinforcement of natural fibers are increasingly regarded as alternative for glass fiber-reinforcement composites. Natural fiber reinforced composite provides some unique advantages for the customers, it includes less weight, bio degradable, and it has very good thermo physical properties. The traditionally used reinforcing glass fibers is replaced by natural fibers such as flax, kenaf, cotton or banana fiber. It can lead to the reduction in components weight and it improves specific properties like impact strength, crash behavior or sound absorption.*
Poor incompatibility between the hydrophilic natural fiber and non-polar polymers leads to negative effect. A variety of silanes have been applied in order to improve its interfacial adhesion and improve the properties of composite. The NaOH concentration had a major influence on the thermo physical properties of the composite. This work is focused on the impact energy absorption structures includes helmet, car bumpers etc., by using High Impact Polystyrene as matrix and Banana fiber as a reinforcement.
***Keywords* - Bio composite, Banana fiber, High impact polystyrene, Impact energy absorption structures**.

I. INTRODUCTION

Abdelmouleh et al discussed about the mechanical performance, thermal properties and water absorbance behavior of four different cellulose fibers with different lengths is considered. Two thermoplastic polymers low density polyethylene and natural fibers are used as matrices. By using silane treated cellulose fiber the matrices are incorporated. The mechanical properties of the composite material is increased with increasing the average fiber length [1]. Sliwa et al discussed about the mechanical and interfacial properties of wood and bio based thermoplastic composite. Composites are prepared by using laboratory size twin screw extruder to obtain the composite pellets and then to the injection molding to make test specimens [2]. Abdullah discussed about the effect of manufacturing process on the flexural, fracture toughness, and thermo-mechanical properties of bio-composites [3]. Faruk et al discussed about the natural fiber reinforced fiber composite and various processing technologies [4]. Xie et al discussed about the effect of silane coupling agents to promote interfacial adhesion and improve properties of composite [5]. Ho et al discussed about the critical factors on the manufacturing process of composite. Ho et al discussed about some critical issues like poor wettability, poor bonding and degradation at the fiber matrix interface along with the damage of fiber during the manufacturing process that leads to reduction of composites strength [6].

Benitez et al discussed about the effect of physical and chemical treatments on the Canary banana fiber and polymers are used as reinforcement, it molded through injection molding process. Sodium hydroxide are used to treat the fiber under various condition of pressure and temperature. The chemically treated banana fiber caused an increase in the thermo physical properties of composite irrespective of the nature of the chemical treatments [7]. Boopalan studied on the mechanical properties and thermal properties of jute and banana fiber reinforced epoxy hybrid composite. This study shows that addition of banana fiber in jute/epoxy composites up to 50% by weight results in increasing the mechanical and thermal properties and decreasing the moisture absorption property [8].

Venkateshwaren discussed about the surface treatment on fiber and its effect on mechanical and visco-elastic behavior of banana/epoxy composite. Various concentration of alkali was used to treat the fiber surface and the effect of these concentration over the mechanical and visco-elastic behavior of composite were carried out. From the study it is found that 1% NaOH treated fiber reinforced composite behaves superior than the other treated and untreated composites. [9], Babu et al discussed about the number of problems present in the milling of natural fibers such as surface delamination and surface roughness, which appear during machining process associated with the material characteristics and various cutting parameters [10]. Hariprasad et al studied about the mechanical properties of banana-coir hybrid composite using experimental and finite element modeling techniques. This work is mainly based on finding the tensile, flexural and impact properties of banana-coir reinforced composite materials with a thermoset polymer for treated and untreated fibers [11], Raghavendra et al discussed about the effect of different fiber lengths with natural rubber and also the matrix fiber interface discussed using SEM [12] Masrol et al investicate the mechanical and the physical characteristics of short, treated and randomly oriented banana pseudo-stem fiber reinforced epoxy composite [13].

Gamon et al discussed about the impact of twin screw extruder on natural fiber morphology and material properties in lactic acid based composites. The shear rate was increased with higher screw speeds, residence time in the extruder and blend viscosity were reduced [14], Mukhopadhyay et al discussed about the fracture behavior of banana fiber with the help of single fiber test and SEM images [15].

II. EXPERIMENTAL DETAILS

1. Materials and Methods

1.1 Matrix Material

High impact polystyrene (LGG-105) purchased from Sandhya Polymers Chennai.

High impact polystyrene properties

The various properties of High impact polystyrene are shown in the TABLE 1

Table 1 Properties of High Impact Polystyrene

PROPERTY	METHOD	UNIT	RESULT
Tensile strength	ASTM D 638	kg/cm^2	116
Flexural strength	ASTM D790	kg/cm^2	23445
Melt index flow	ASTM D 1238 G	g/10min	5.19
Impact strength	ASTM D 256	Kg cm/cm	1.22
Vicat Softening temperature	ASTM D 1525	˚C	98

1.2 Reinforcement Material

Banana fiber purchased from CIPET Chennai

1.3 Surface treatments on banana fibers

Treated and untreated banana fibers are used for the manufacturing of composite material. Hence the banana fibers undergoes as series of chemical treatments namely alkali, Benzyl chloride, and potassium permanganate along with coupling agents, Banana fibers were copped in to 6cm before giving the treatment.

1.3.1 Alkali treatment

The 6cm chopped banana fiber are washed with detergent to remove dust and other impurities present over the surface. The chopped fiber is dipped with NaOH solution with various concentrations (1N, 2N) for 6 hours. Then the fiber is washed thoroughly using running water to remove the alkali content present in the fiber. Fiber were dried until the moisture content is completely removed.

1.3.2 Benzoyl chloride treatment

Chopped fibers (6cm) were soaked in 2% NaOH solution for half an hours and then well agitated with benzoyl chloride solution for 30 minutes. The fibers were later washed with water and then dried completely.

1.3.3 Potassium permanganate treatment

The alkali treated banana fibers were choked in 0.5% $KMnO_4$ for half an hour and the fiber were dried in the air.

1.3.4 Silane treatment

The chopped banana fiber were soaked in water containing silane coupling agent 3-Aminopropyltriethoxysilane. The fibers were allowed to remain there for 2 hours and then the fiber is removed and then dried.

1.4 Composite fabrication

The natural fiber reinforced composite is fabricated by twin screw extruder followed by injection molding. Twin screw extruder is used for compounding and test specimens were prepared by using injection molding.

1.4.1 Twin Screw Extruder

Compounding is done by twin screw extruder, where the matrix and the reinforcement are thoroughly mixed. The various zone temperature that should be maintained are shown in the TABLE 2

Table 2 Various Zone temperatures for Twin Screw Extruder

Type	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6

	(˚C)	(˚C)	(˚C)	(˚C)	(˚C)	(˚C)
Temp	145	165	180	195	205	215

The chopped banana fiber and high impact polystyrene are mixed by the rotation of screws present inside the extruder. The screw rpm are maintained at 60. The die has 3mm diameter hole through which the composite material is obtained in wire form. These material pass through pelletizer and made into small pellets. These pellets are put into injection molding to produce test specimen. The pictorial view of twin screw extruder is shown in Fig 1

Fig 1 Experimental setup of twin screw extruder

1.4.2 Injection Molding

Injection molding is used to make ASTM standard test specimens, where the pellets are put into the hopper and then it injected through the nozzle to the die. The pictorial view of injection molding is sown in the Fig 2

Fig 2 Experimental setup for Injection molding machine

ASTM standard test specimens for Tensile, Flexural and Impact are shown in Fig 3

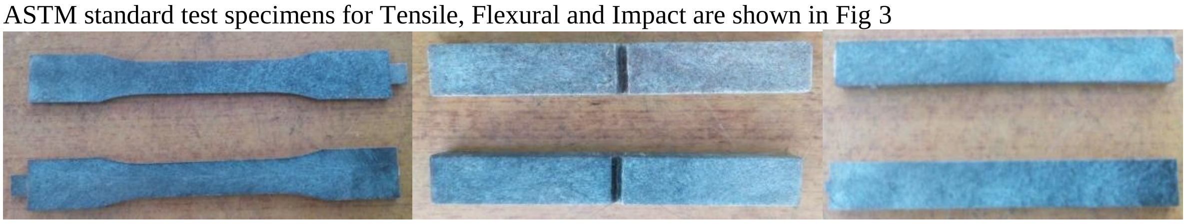

Fig 3 ASTM standard specimens

III. III RESULT AND DISCUSSSION

TESTING OF COMPOSITE MATERIALS

IMPACT TEST

Impact plays a major role in determining the life of the structures. Izod impact testing is the ASTM standard method (ASTM D256) of determining the impact resistance of the material. It consists of an arm held at a specific height and then released. The arm strikes the sample and breaks it. From the energy absorbed by the sample the impact energy is determined. A notched sample is generally used to determine impact energy and notch sensitivity. The results are expressed in energy lost per unit of thickness (J/cm) at the notch. The different test results are shown in TABLE 3

Table 3 Test results for various trials

Type of sample	Untreated fiber (J/m)	1N alkali treated fiber (J/m)	2N alkali treated fiber (J/m)
Trial 1	110	130	120
Trial 2	100	130	120
Trail 3	100	120	130
Trail 4	110	130	120
Trail 5	100	130	120

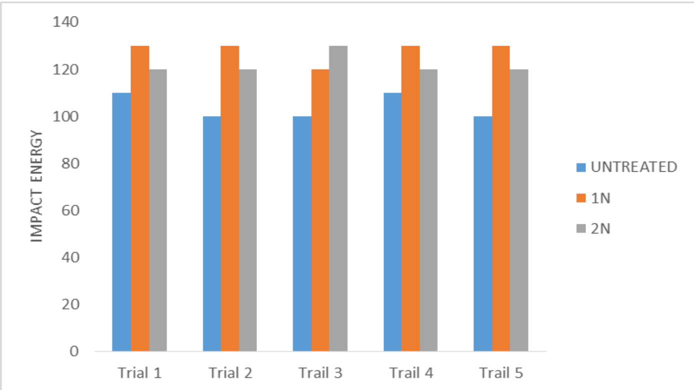

Fig 4 Comparision of impact strength in untreated and treated banana fiber

The 1N treated banana fiber posses more impact energy when compared to the untreated and 2N treated banana fiber. The alkali treatment plays a major role in determining the impact strength of the composite.

IV. IV CONCLUSION

Natural fiber reinforced composites are become more commercialized and various researches are going on. Natural fiber composite are possess low processing temperature (for high impact polystyrene is about 220˚C), and the various chemical treatments provide better mechanical properties. The 1N sodium hydroxide treated banana fiber produces better impact strength than both untreated and 2N treated banana fiber. The most challenging factors in this natural fiber reinforced composite materials is thermal stability of the fibers, if there is any significant improvement in thermal stability of fiber means it produce better results and it is the main area where the people should concentrate.

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