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A Experimental Analysis of Bamboo/Jute/PLA Biodegradable Composite

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Abstract- Natural fiber reinforced composites or green composites plays an important to replace manmade fiber reinforced polymer composites because of availability, economic in use, recyclable, also possessing a good mechanical strength, usage of bamboo, jute, and other natural fibers can served a better option for green composites. According to reviewed literature use of bamboo material is limited in use because of hydrophilic nature with also surface roughness. The present article report discusses a detailed investigation of mechanical, morphological, properties of bamboo and jute fiber reinforced poly-lactic acid bidirectional void free composites was carried out by compression molding machine. Mainly this was carried out to show its advantages in use like in wider applications as in structural, furniture's etc. Tensile, flexural testing was done to evaluate the strength and modulus properties, whereas morphological analysis of surface was evaluated by scanning electron microscopic analysis. The analytical results showed approximated results with the experiment results. On comparing Jute and Bamboo fiber reinforced composites, Bamboo fiber reinforced with jute shows better stiffness properties (Tensile modulus and Flexural modulus).

Keywords: - Bamboo Fiber, Jute Fiber, PLA.

I. INTRODUCTION

As we know, at some time conventional materials are in greater use because of its various properties and applications in use. But now a days, there is demand to supersede that materials with materials which do not harm the environment and ecology because of highly using limited stock of resources available (minerals and ores), so in present scenario researchers and developers are highly devoted to develop the environmental friendly material which is also economical.

So, to replace or supersede those materials, composites have achieved the greater attraction in place of metals, polymers, wood, and many more because of its possessing higher stiffness with greater strength. Composites in present time have spreading in various sectors like from air crafts manufacturing to toy making because of its tailor made properties like its weight as compared to its possessing strength. These materials are coming generation materials because of its containing higher potential than many more materials or say nano composites or smart material.

Generally, polymer matrix composites it is one of the composite type which possesses a greater use now a days because of its advantages, as durability with light weight, corrosion resistant, high strength to weight ratio etc.

Mainly used polymer composites are making by using glass, carbon, aramid etc. because of its self-possessed strength also vibration damping capacity. These fibers making composite are using in various industries like automobile, sports equipment, structural applications and many more. But to keep

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in mind the environmental and ecological condition or rules or its degrading resources because of it is highly usage biodegradable fibers are in limelight. So, now researchers are contended to develop the fully biodegradable composite.

II. MATERIALS AND METHODS

1. Materials:

In making of composite following fibers and polymers have used:

1.1 Poly-lactic acid (PLA):

Poly-lactic acid (PLA) is available in wide variety used in processes which is provided by (Nature Tec India Pvt Ltd, Chennai) PLA was imparted in the form of pellets with having specific gravity 1.25 gm/cm3 PLA is thermoplastic polymer that is prepared by fermentation process of plants starch like corns, sugarcane , cassava etc.

Table 1. Physical properties of PLA resin [Ref: Technical data sheet (In geo TM Biopolymer 3052D).

Physical Properties	Ingeo Resin	ASTM Method
Specific Gravity (gm/cm3)	1.24	D792
MFR, gm/10 min (210 °C, 2.16 kg)	14	D1238
Relative Viscosity	3.3	
Crystalline Melt Temperature(c)	145-160	D3418
Glass Transition Temperature(°C)	55-60	D3418
Clarity	Transparent	

Fig 1. PLA pellet.

PLA generally provided in pellets form which is converted in sheet form to prepare the final composite with the help of compression moulding machine. Firstly as PLA is hydrophilic in nature so before sample preparation its removal of moisture is important to get a crystalline structure without any defects.

PLA is dried in oven maintaining temperature at 45-50 °C for approximately 4 hours, after that as we have available mould size in compression moulding is 23×26×6 cm; preparation of a sheet is as follows.

1.2 Fibers:

Generally, two fibers have been used as detailed following:

1.2.1 Bamboo Fiber: Bamboo fiber is obtained in various forms like in woven type figure 3.5 in unidirectional figure 3.4 and more. The fiber was cut according to the mould size of 23×26 cm of around 1.5-2 mm thickness as shown below figure 3.5. The bamboo fiber is generally hydrophilic in nature that so it is needed to remove its moisture for its best performing properties.

It is dried in digital temperature controller oven for 12-15 hours at 30-35 °C so to remove its moisture completely. After drying fibers were packed and closed so that it can retain moisture.

As, W1 is weight before drying = 41.18gm
W2 is weight after drying= 38.25gm
Percentage of moisture content =W1-W2 W1
As above shown the moisture content is_ 7.115%

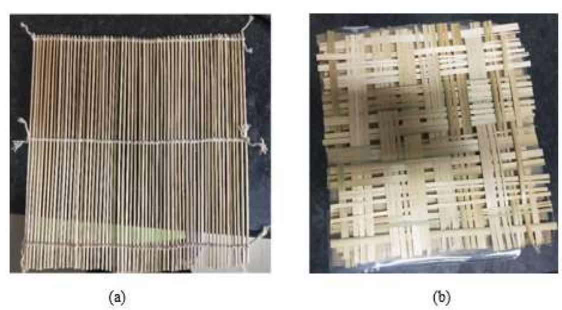

Fig 2. Jute fiber.

1.2.2 Jute Fiber:

The sustainable development with higher strength is the growing demand of construction industry. Concrete reinforcement by natural fibers are more promising to insure the concrete strength improvement with non-hazardous impact on environment as well as the effective use of available natural assets. To achieve this goal, numerous researchers have used the fiber as well as yarn very effectively as a concrete reinforcing material. The fibers can insure the post-cracking resistance, high-energy absorption features, and increased fatigue resistance of cement-based composites.

Among two different types of fibers, i.e., natural fibers and artificial polymer-based fibers, natural fibers are promising to use as reinforcement to overcome the inherent deficiencies in FRCC reinforced with polymer-based fiber. The main deficiencies associated with the use of artificial fibers are relatively high cost and health and environmental hazards.

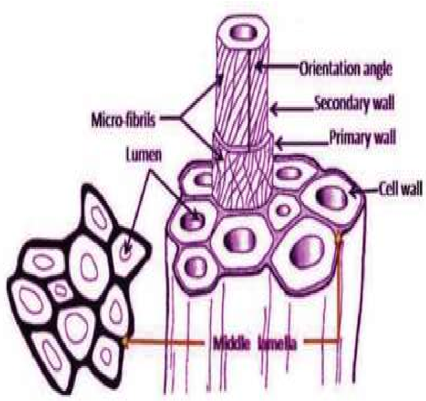

Figure 3. Structure of Jute Fiber. [3]

Jute fibers are available in various types the common type is or variety is Bangla Tosha-Corchorus olitorius and Bangla White- Corchorus capsularis.

1.2.3 Composite Fabrication:

For composite fabrication first the layered wise form of Polymer and fiber is made fig. (PLA/ Jute/ PLA/ Bamboo/ PLA/ Jute/ PLA). This layered combine form of polymer and fiber is then put inside the compression moulding machine as plastic sheets is used at upper and lower side of composite for good surface finish fig. at a temp maintained formerly at 130-135ºC in equilibrium (top heater and bottom heater) so the machine can adjust the composite with uniform pressure applied.

As pressure is applied 45-50kg/cm2 as optimizing after iteration it is enough pressure for completely closed the mould and for good composite making fig. Now this pressure is applied with increasing temperature uniformly heating by heaters, when it is reached at 150ºc and it is maintained for approximately 25-30 minutes so that the polymer gets completely melted and settled inside the mould. After, completing the process solidification of composite is required which is generally done at 80-85ºC of compression moulding machine .At that temperature composite is taken out with air cooling requires 10-15mins for completion.

Fig 4. Jute/Bamboo PLA arrangement before composite formation.

Fig 5. Arrangement of Jute/bamboo/PLA inside compression moulding.

Fig 6. Compression moulding machine.

Fig 7. Composite specimen from compression moulding machine.

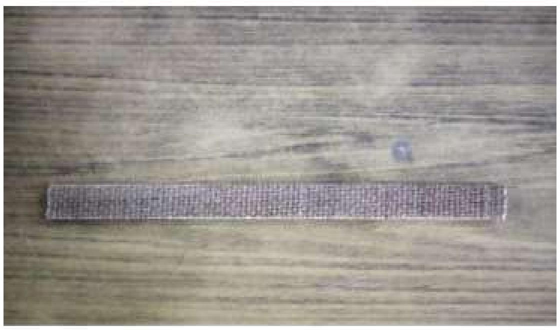

Fig 8. Flexural test specimen.

Figure 9. Tensile test specimen.

1.3 Characterization:

For characterization of composite Tensile and flexural testing have been done as describing under following:

1.4 Mechanical Testing:

Tensile test and Flexural test were carried out on Universal Testing machine (Instron-5982). Tensile test specimen was fabricated according to ASTM-D3039 standard. With respect to standard the sample size is 5 with individual gauge length 90mm with 4 mm thickness and fixed cross head of 1mm/min. Tensile properties were measured with respect to tensile strength and tensile modulus.

Flexural test specimen was fabricated according to ASTM-D7264 standard. Also 5 samples were tested with span length of 60mm with 4 mm thickness by taking cross head speed 1mm/min. Flexural test were measured by flexural strength and flexural modulus.

III.RESULTS AND DISCUSSION

1 Mechanical Properties:

1.1 Tensile Properties:

As According to ASTMD3039 i.e. Standard Test method for tensile testing of polymer matrix composites specimen was prepared and tested 5 samples were tested and results were shown in fig as summarized with this so, it is depicting that tensile strength relates to interfacial bonding or interface bonding between fibers and polymers whereas sample 1 shows maximum tensile strength .i.e.28.037 MPa and minimum by sample 2 i.e. 13.113 MPa maybe because of poor interface bonding.

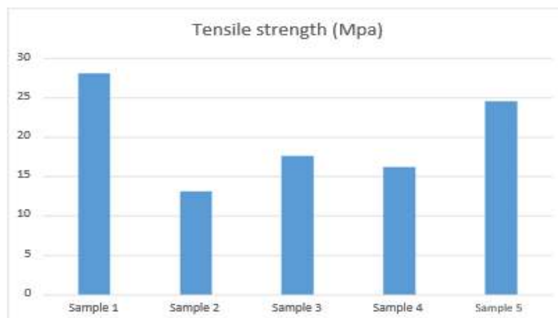

Fig 10. Tensile strength of composite.

Tensile test gives tensile strength and tensile modulus which combined shows the tensile behaviour of composite material. Tensile modulus shows stiffness in composite material. As exhibited from the fig. sample shows the maximum tensile modulus 1956.108 MPa and minimum by sample 5 i.e. 1250.524 MPa.

Fig 11. Composite sample after tensile test (sample1).

1.2 Flexural Properties:

As according to ASTMD7264 i.e. Standard test method for flexural strength of polymer matrix composites specimen was prepared and tested Shown in figure 4.5.

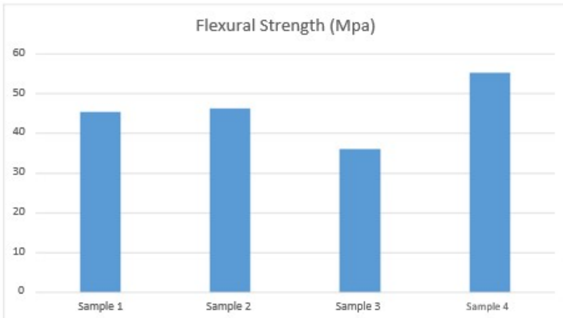

Fig 10. Flexural strength of composite material.

1.3 Morphological Observations:

1.3.1 SEM Analysis:

Now as test performed on samples, after that composite samples surface need to be analysed and inner microstructure need to be studied. So, the SEM analysis is the process to study the micro graphical behaviour of composite in which various things are analysed like interfacial bonding between fiber and resin Micro cracks and cracking behaviour of fiber.

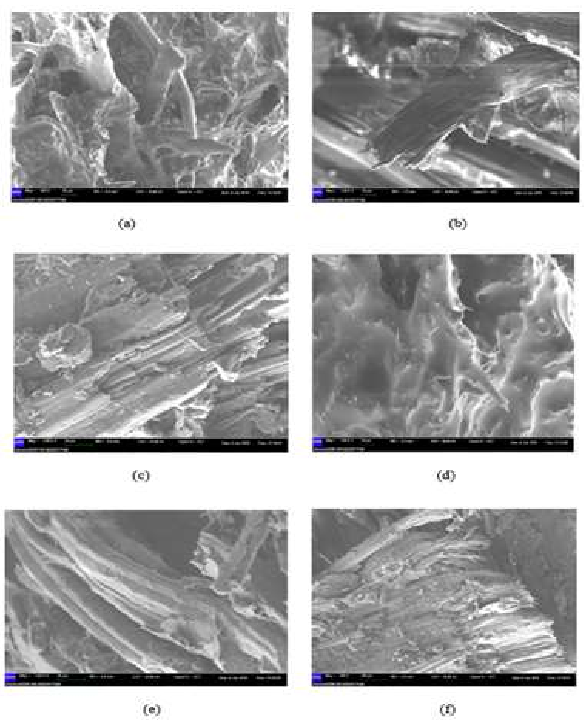

Fig 11. SEM images of composite surfaces after tensile failure (a), (c), (d), (e) surface exposure (b) Inner microstructure (f) Side surface exposure.

As Figure shows the SEM images of composite structure after tensile failure it is shown that various types of information displayed that in Figure (a),(c),(f) shows the fiber crack generated inside the composite material that means the interfacial bonding between the polymer and fiber is virtuous but adhesion is not so good as seen that inner voids are generated where polymer does not get filled.

Whereas in figure (b) it is reveal that fiber pull out failure is done which shows the bad interfacial bonding and not proper adhesion in between fiber and polymer. In Figure (d) extremely impregnation of polymer is shown which shows non uniform distribution of polymer because of pressure and temperature applied.

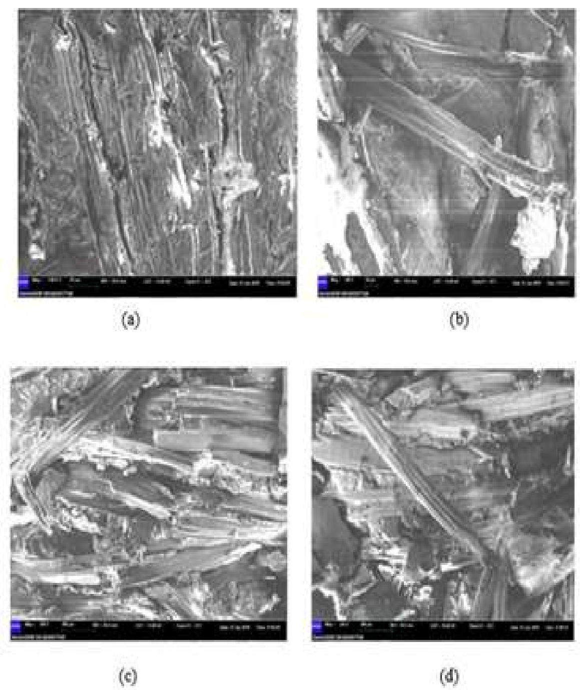

Fig 12. SEM images of composite material after flexural test.

As shown in Figure SEM images of composite material after flexural test was performed to analyze the breakage behavior of fiber is analyzed.

Whereas, it is clearly seen that in figure 11 (a), (c) cracking of fiber is shown without pulling out of fiber which resembles the better interfacial bonding and in figure 4.10 (b), (d) pulling out of fiber is seen where voids are also present which shows the not proper impregnation of polymer inside the composite structure.

IV.CONCLUSIONS AND FUTURE SCOPE

1. Conclusions:

In the present experimental work, Bamboo and jute used as a fiber and PLA as resin material bio composite specimens have been developed by compression moulding machine. The specimens according to ASTM standards were tested and analyzed by SEM process. A thorough characterization of samples has been performed.

The following inferences can be drawn from the results were:

Hydrophilic nature of bamboo has shown some disadvantages for interfacial bonding between bamboo and PLA. This can be shown in SEM images where fiber gets pulled out during tensile testing.

Bamboo fiber incorporation with jute and polymer as PLA shows better flexural strength and also tensile strength if adhesion is proper and interlocking between fiber and polymer is good.

During flexural testing when load applies, PLA starts removing from the surface which shows the brittle nature of PLA.

By optimizing the temperature and pressure composite can be made with more tensile and flexural strength. As optimization done it is shown that 45-50kg/cm2 and temperature about 150-155 ºC.

Better stiffness is correlated with Bamboo fiber than strength possessed by the composite.

2. Future Scope:

In the present study, effect of hydrophilic nature on mechanical properties was analyzed. Also the surface roughness of Bamboo fiber resists incorporation of polymer layer which degrades the quality of composite. So, for further improvement surface treatment can also be a solution to improve the mechanical properties as well as surface texture.

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