International Journal of Management, IT & Engineering
Vol. 8 Issue 7, July 2018,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

CHARACTERIZATION AND DEVELOPMENT OF BIOCOMPOSITES FROM JUTE & COIR FIBRES

Dinesh Y N*

Murugesh Babu K*

ABSTRACT

Composites are widely used in our daily life. Due to their low weight and ability to be tailored for specific end use they have gained a considerable ground in the high performance applications, such as aerospace and automobile industry. However, the use of polymers that can be recycled when used with carbon and other niche fibres render the composite non-recyclable. This has become a major issue as the landfills are filling up at a faster pace along with the need for going green due to global warming. To tackle these issues research in recent years has been focused on substituting non-biodegradable based composites with bio-degradable ones. In order to achieve the goal of recyclable and biodegradable composites, natural fibres are the best choice for production of fibre reinforced composites. The overhead for using natural fibres is their cleaning and processing needs. Bio-composites were produced using jute and coir as reinforcing phase and epoxy (L-12) resin as continuous phase. Compression moulding technology was used to produce the composites and curing was done at a temperature of 120^{o} C for 20 minutes. Square shaped moulds were used for this purpose. Composites were produced using two different composition of fibres (50:50 and 60:40) and at two different fibre lengths (3cm and 6cm). Fibres were characterized for various physical properties like morphology, density, moisture regain, water absorption and mechanical properties. Fibres were also characterized using Thermo-gravimetric analysis (TGA). It was found that jute and coir can be used for production of composites, to be used for domestic purpose. Composites were tested for

* **Dept. of Textile Technology, Bapuji Institute of Engineering and Technology Davangere – Karnataka, India**

various properties like moisture regain, tensile strength and bending stress. Study revealed that the properties of composites depend on type of fibre, length of fibre and % of fibre used for producing the composite.

Key Words: Jute, Coir, Bio-composites, Epoxy

1. Introduction

Composites have become an integral part of our day-to-day life and can be found everywhere, e.g. rubber tire, spacecraft, asphalt etc. Composites have been around for a long time with the classic example of bricks made from straw and mud. With the development of new high performance fibres, composites began to compete with metals, and replace them, in myriad applications. Fibre reinforced composites ventured into areas which were unthinkable few decades ago, making the products light weight, improving the performance of the product and in some cases improving the life time too. Better mechanical properties of these composites are due to excellent interfacial adhesion between fibre and matrix, in addition to good mechanical properties of fibres. However the good interfacial adhesion between fibre and matrix, which is beneficial in the product, is a significant disadvantage in the products “afterlife” since the fibres and matrix cannot be separated easily. This impairs the recycling of either or both. Also these fibres are not easily compostable; hence the composites cannot be used to recover energy. Natural fibre reinforced composites are becoming the best alternatives in various fields where glass fibres were used as reinforcement [1, 2]. Manmade fibres require high energy inputs for their manufacture [3], are not environment friendly and are not biodegradable. As the concern over environment is increasing, scientists all over the world are trying to use biodegradable natural fibres (plant fibres) for producing fibre reinforced composites as alternative to the manmade fibres. [4,5,6,7]. Two main reasons for the interest in biodegradable materials are: (1) the growing problem of waste thereby resulting in general shortage of landfill availability, and (2) the need for environmentally responsible use of resources together with the carbon dioxide neutrality aspect [8]. Plant fibres are becoming attractive raw material for producing composites due to their low cost, high strength to weight ratio [9, 10] and ease of processing. Plant fibres have certain disadvantages when used as reinforcement material such as lower impact resistance, high moisture and water absorption and lower thermal stability which may affect their long term performance. Based on above idea, in this paper an effort is made to develop bio-composites from eco-friendly fibres. Natural fibres like jute and coir were used as reinforcing phase and epoxy resin was used as matrix material. Different lengths and weight fraction of fibres were used to see the effect of these parameters on composite properties.

2. Materials and Methods

2.1 Materials

a. Resin: Epoxy resin (LY 554) was used and was locally procured.

***b. Hardener*:** Araldite HY 951 was used as hardener.

***c. Fibres*:** In the present work natural fibres like jute and coir were used as reinforcing materials to develop bio-composites. Jute was procured from local market of Patna, Bihar, and coir was procured from Siddeswara Coir Industries, Birur - Karnataka.

2.2 Methods

a) Fibre Testing Methods:

i. ***Fibre Length:*** The length of natural fibres was measured with the help of standard laboratory scale.

ii. ***Fibre Thickness:*** The thickness (Approximate) of natural fibres was tested using thickness Gauge and was expressed in mm.

iii. ***Fibre linear density (Tex):*** The fibres were tested for fibre Tex count by measuring their length and weight

iv. ***Moisture content and water absorbency:*** It was found out by using Paramount hot air oven; Amount of water absorbed after soaking the fibres in water for 30 min. was also found

v. ***Microscopic Appearance:*** The longitudinal and cross section of the fibres were observed under the "**Carl Zeiss**" digital microscope with (10X10 magnification).

vi. ***Fibre strength:*** Fibre tensile strength and elongation were found using Universal Tensile Strength tester using standard procedure.

vii. ***Thermo Gravimetric Analysis* (TGA):** Thermo gravimetric analysis of fibres were done using TA universal tester 5000. Sample weight taken was 20mg and heating rate used was 20º C/min and nitrogen (inert) atmosphere was used for the purpose. Temperature of onset of degradation, final temperature and percentage residue were found out.

Viii ***Density:*** Specific gravity of the fibres was found out solvent immersion method. Heptane was used as solvent.

b) Composite Production:

Composites were produced using compression moulding technique. Rectangular mould of size 25cm×25cm was used. Jute and coir fibres were cut to two different lengths of 3cm and 6cm. Before production of composites the jute fibre was scoured and was thoroughly cleaned and coir fibre was also cleaned by hand. Following ratios (**Table 1**) were used for the composite production. Fibres were manually mixed with the resin before moulding and the consolidated (moulded) composites were cured at 120˚C for 15 min. Schematic representation of composite moulding process is shown in **Figure 1**.

Table 1. Fibre/Resin (w/w) Ratios chosen for composite preparation

Ratio (fibre: resin)	**Weight of fibre (g)**	**Weight of (resin + hardener) (g)**
50:50	156	156
60:40	180	120

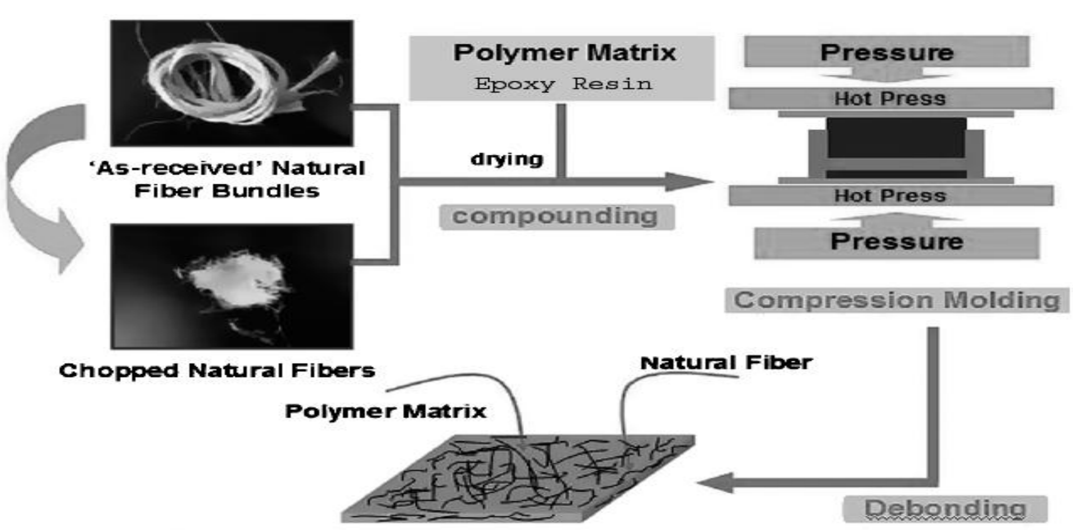

Fig. 1 Schematic representation of compression moulding process

c) Composite Testing:

i. **Moisture content:** The moisture content of the composite was tested using the same method which was used for finding the moisture content of fibres.

ii. **Thickness:** Thickness of composite was found out by using screw gauge.

iii. **Bending stress:** To test the bending stress of composites, 3 point bending principle was used. A separate arrangement was made in the form of clamp (for the span length of 170 mm) to place the specimen. A sample of (223 x 36 x 10 mm) length ×width ×thickness in mm was used for testing. The bending stress of composites was calculated using the formula:

Bending stress (N/mm^2) = $3PL/2bd^2$

Where,

P = Maximum load in Newton

L = Span length in mm

b = Width of specimen in mm

d = Thickness of specimen in mm

iv. Tensile Strength

To study the mechanical stability of the composites, tensile strength test was carried out using Universal Tensile Tester. The length and width of the sample were 225 mm and 40 mm respectively. The thickness of the sample was 10 mm. the gauge length was set at 100 mm and speed of testing was 5mm\min.

3.0 Results and Discussion

3.1 Dimensional Properties & Microscopic Appearance of fibres

Fibre length, linear density, fibre thickness & density of jute and coir fibres are presented in the **Table - 2** & microscopic appearance (longitudinal & cross section) is presented in **Figure 2.** From the tables & figure following observations are noteworthy.

- Both the fibres exhibit very high variation in the all dimensional properties.
- Both the fibres were coarser, much coarser than conventional textile fibres.
- Density of the coir is less than that of jute.

- Both the fibres show irregular cross section & in the longitudinal section bundle of fibres could be visualized.
- Since both the fibres have irregular cross section, these fibres can be expected to have better mechanical adhesion (lock and key mechanism) with the matrix material.
- Since the density of these fibres is less than conventional reinforcing fibres (inorganic fibres), these fibres are expected to give FRC's of lower weight.
- Even though fibres as a whole are coarser, the ultimate in each fibre is finer which overcomes the limitation of coarseness there by allowing the adhesive to enter into each fibre.

Table 2. Dimensional Properties

Fibre	**Length (cm)**	**Fineness (Tex)**	**Thickness (mm)**	**Density (gm/cm^3)**
Jute	150-200	3.2	0.25	1.4
Coir	10-22	57	0.6	1.2

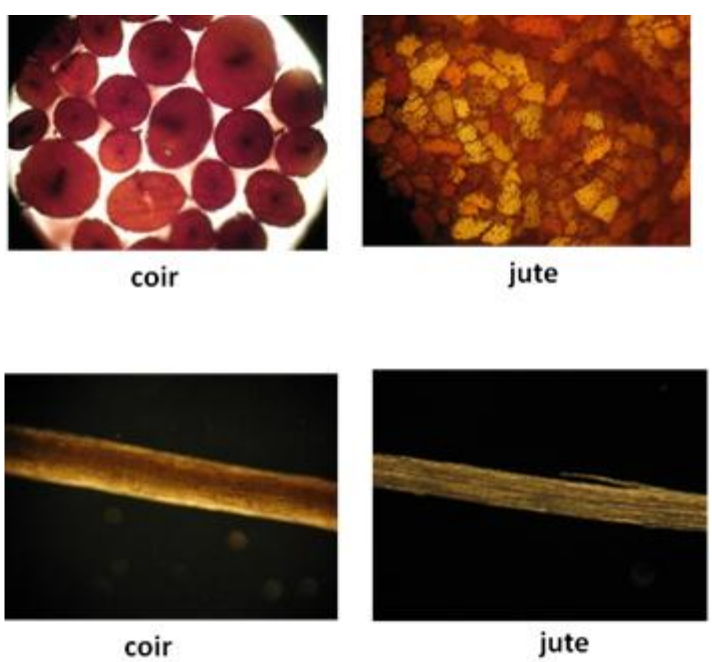

Fig. 2 Cross-section and longitudinal section of different fibres

3.2 Moisture regain and water absorption

Moisture regain and water absorption data are presented in **Table - 3**. From the table one can observe that both the fibres are hydrophilic and water absorption capacity of both the fibres is very high. This property may become detrimental as high moisture absorption may lead to low dimensional stability of composites made from these fibres and the dimensions of the composites might vary according to humidity of the atmosphere. More over if fibres absorb moisture, various other properties of composites also might vary depending on atmospheric conditions leading to poor performance of composites made from these fibres.

Table 3. Moisture content and water absorption of various fibres

Fibre	**Moisture content (%)**	**Water absorption 30 min (%)**
Jute	11.5	90
Coir	9.2	85

3.3 Tensile properties

Tenacity %elongation at break and initial modulus of these fibres are presented in **Table 4.** From the results it can be seen that jute fibres are stronger and stiffer than coir fibres.

Table 4. Tensile properties of fibres (65% RH)

Fibre	**Tenacity (g/tex)**	**Elongation at break (%)**	**Initial modulus (g/Tex)**
Jute	44	1.5	1280
Coir	17.2	14	353

3.4 Thermo Gravimetric Analysis (TGA)

TGA data for these fibres are presented in **Table - 8** and the TGA trace for the fibre is given in **Figure 3 and 4.** It can be seen that on set temperature, temperature at maximum weight loss and the final temperature (beyond which there is no weight loss) is more for jute fibres (352ºC, 388ºC and 406ºC respectively) than coir fibres (303ºC,351ºC and 374ºC respectively). This reveals that jute fibres can be used to produce composites which are more thermally resistant than coir fibre reinforced composites.

Table 5. Thermal Properties of fibres (TGA)

Fibre	**Onset temperature (°C)**	**Maximum temperature (°C)**	**Final temperature (°C)**	**Residue (%)**
Jute	352.85	388.9	406.5	12.93
Coir	303	351.43	374.3	23.33

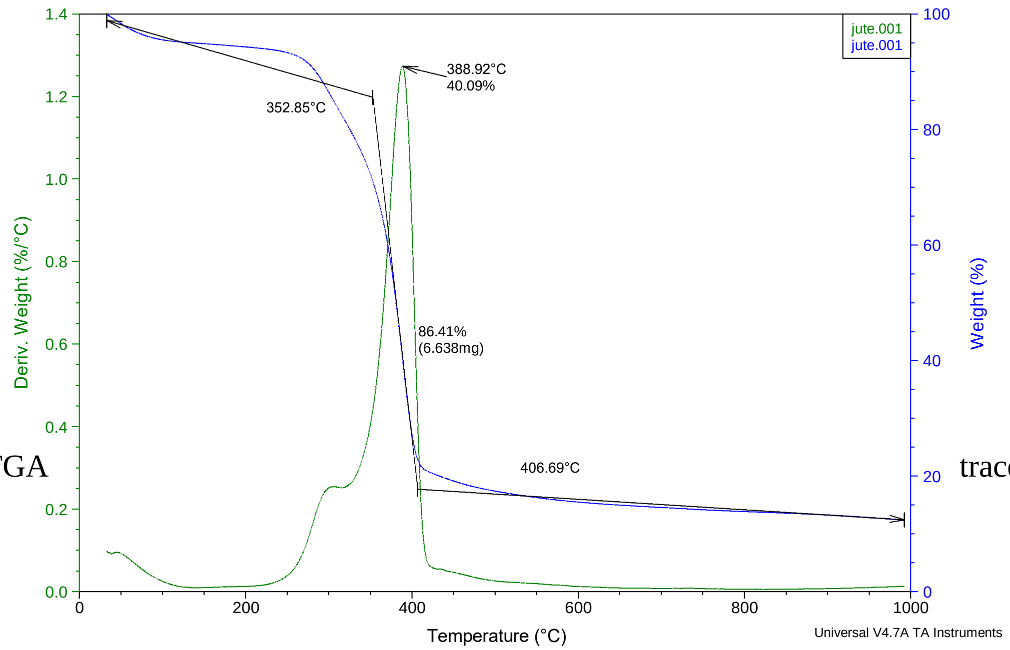

Fig. 3 TGA trace of jute fibres

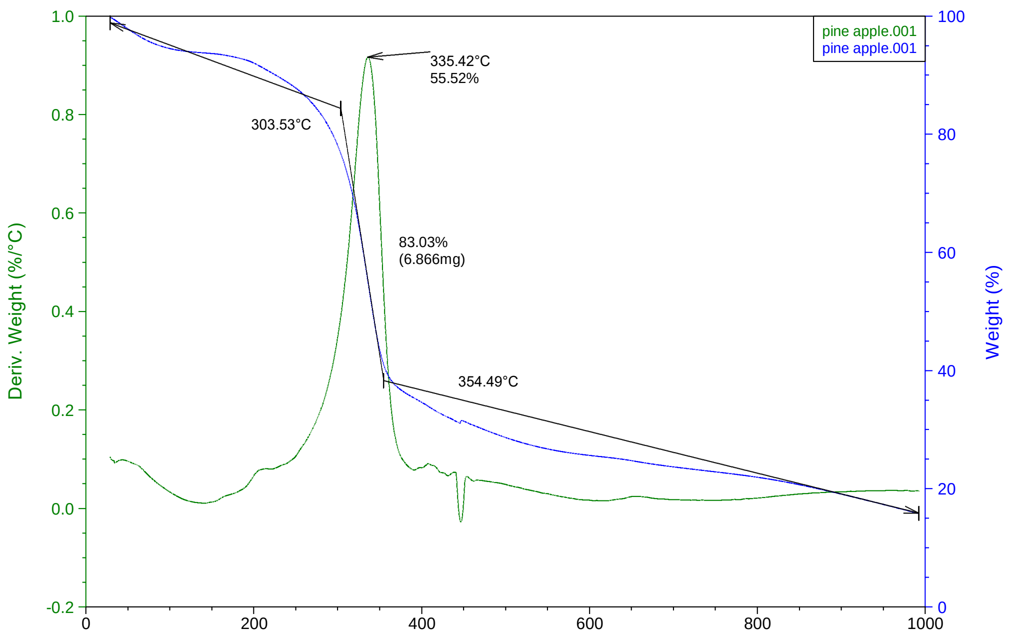

Fig. 4 TGA of coir fibre

3.5 Composite Properties

i. Composite Moisture Regain:

Moisture regain (%) values of jute/epoxy and coir/epoxy composites are presented in **Table 6.** Moistur**e** regain increases as the fibre content is increased. This trend is same for both jute and coir fibres. Length of the fibres used for production of composites does not show any effect on moisture regain of composites. Moisture regain of composites made from jute fibres is found to be more than moisture regain of composites made from coir fibres. 10% increase in fibre content increases moisture regain by about 25% in the composites made from these fibres. Reason for higher moisture regain of jute/epoxy composites is due to higher moisture regain of jute fibres than coir. Epoxy being hydrophobic leads to reduction in moisture regain as its % is increased. Moisture regain of these composites is higher than composites made from glass/epoxy. This might become drawback of bio-composites resulting in change in the dimension and mechanical properties of the products made by them depending on the relative humidity of the atmosphere. Suitable surface coating might be required to control the entry of moisture into the composites, especially when these composites have to be used for outdoor applications.

Table6. Moisture regain of composites

Fibre Length (cm)	**Ratio**	**Moisture regain of jute/epoxy**	**Moisture regain of coir/epoxy**
3	50:50	1.7	1.09
6	50:50	1.5	1.12
3	60:40	2.1	1.36
6	60:40	2.2	1.39

3.6 Bending stress: Bending stress values of jute/epoxy and coir/epoxy are presented in **Table 7** Here the stress required to break the composite by applying flexural force is determined. From the results, it can be seen that bending stress value is more for jute/epoxy than coir/epoxy. As the % of fibre in composite is increased from 50-60% bending stress is found to increase by about

11% in case of jute fibre reinforced composites and in case of coir fibre in reinforced composites the increase was about 12%.

Table 7 Bending stress of composites

Fibre Length (cm)	**Ratio**	**Bending stress (N/mm^2) Jute/epoxy**	**Bending stress (N/mm^2) coir/epoxy**
3	50:50	18.2	13.5
6	50:50	18.9	13.8
3	60:40	20.2	16.6
6	60:40	20.6	15.5

During bending, combination of tensile, compressional and flexural forces will be acting on the sample. Since jute fibres have more tensile strength than coir, jute fibre reinforced composites exhibit higher bending stress. As the % of fibres in composite increases, load bearing capacity increases resulting in increase in bending stress. Length of the fibre used for making these composite does not show any significant effect with respect to bending stress values.

3.7 Tensile strength: Data for tensile strength of various composites is presented in **Table 8** Breaking load of jute fibre reinforced composites is more than coir fibre reinforced composites for all the lengths studied. Jute fibre reinforced composites show breaking load of about 2.45KN, whereas coir fibre reinforced composites show 1.1KN of breaking load at 50:50 ratio of fibre and resin (6cm length). In both the composites breaking load is found to increase with the length of fibres as well as % age fibres.

Table 8 Tensile strength of composites

Fibre Length (cm)	**Ratio**	**Breaking load (KN) Jute /epoxy**	**Breaking load (KN) Coir /epoxy**
3	50:50	2.2	0.95
6	50:50	2.45	1.1
3	60:40	3.2	1.5
6	60:40	3.4	1.9

The reason for above observations can be attributed to:-

- Jute is comparatively stronger fibre than coir. Hence, when jute is reinforced in epoxy resin, the composite produced will be stronger than coir/epoxy composites.
- As the length of fibre increases, cohesion between fibres and the resin increases and number of weak points (fibre ends) decreases, resulting in enhanced stability of composites. As the % of fibre increases, strength of composite increases due to better reinforcement.

4. Conclusions:

- Eco-friendly fibres like jute and coir can be used to make bio-composites.
- The mechanical properties of these fibres are inferior to that of high performance fibres which are generally used for production of composites.
- Both the fibres are hydrophilic and susceptive to moisture and water.
- Both the fibres can be successfully converted into composites using compression moulding technique.
- Moisture regain of the composite is more in jute fibre reinforced composite and is found to increase when the fibre content is increased.
- Breaking load of jute fibre reinforced composites is more than coir fibre reinforced composite and breaking load is higher at higher length and high % of fibres.
- Bending stress of jute fibre reinforced composites is more than coir fibre reinforced composites and is found to be more at high %of fibers

REFERENCES

1. Bolton, J. Mater Technol 1994, 9, 12.

2. Sanadi, A. R; Prasad, S.V.;ROhatagi, P.K.J Sci Ind Rec 1985,44,437.

3. Jeronimidis, G. In Concise Encyclopedia of Composite Materials; Kelly, Ed.;Pergamon: Oxford, 1994; 204.

4. C.A.S Hil, h.P.S. Abdul Khalil, M.D. Hale, a study of plant fibr, Industrial crops and products ,1998,53

5. I.K. Varma, S.R.A Krishnan, S. Krishnamoorthy, Textile Research Institute 58(9) (1988)537.

6. K.G. Satyanarayana, K. Sukumaran, S. G. K. Kulkarni, P.K. Rohatgi, Composites 17,1986,329

7. E.T.N. Bisanda, M.P. Ansell, Compositics Science and Technology 41(1991) 165.

8. Mohanty, A. K., Misra, M., Hinrichsen, G., *Macromolecular Materials and Engineering*, **276/277**, 1, 2000, 1.

9. S.P. Carruthers, in: s.P. Carruthers, F.A miller, C.MA. Vaughan (eds.), Crops for Industry and Energy. CAS Report 15, 1994, .93.

10. A.J. Bolton, Natural fibres for plastic reinforcement, Mat. Tech. ½,199412.