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**ABSTRACT**

Jute is an important natural fibre occupying second place in economic importance only to cotton. More importantly it is a commodity on which many households in the country depend for their cash earnings. However, the contribution of jute fibres for technical applications is limited at present. In this research, the suitability of jute fiber when incorporated into epoxy matrix was studied in an investigative series of experiments with a view to widen the share of jute fibers for engineered applications. Composite specimens containing nonwoven jute mat and alkali treated short jute fibers with different weight percentages (1, 2 wt%) were prepared and subjected to thermal analysis in order to study the effect of fiber geometry on thermal behavior of composites.

**KEYWORDS:** composites, nonwovens, jute fiber, fiber geometry, thermal analysis.

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**INTRODUCTION**

Jute fiber represents one of the essential economic assets of our country as we lead in the production of this golden fiber just next to cotton. The main traditional use of jute has been for the packaging market. Cloth, sacks and bags made of woven jute fabrics are widely used for transportation and storage of agricultural products, fertilizers, cement and some chemical products [1]. Though, biodegradability, renewability, copious mass production combined with a low cost base are some of the chief reasons to utilize this fiber beyond its conventional fields. The contribution of jute fibres for technical applications is limited at present due to captive domestic market of jute sacking required for bagging of foodgrains and sugar in jute bags, emanating from jute packaging materials [2]. In order to facilitate jute production, uses and exports, it is necessary to stimulate new demand in consumer markets, both to retain the present market share for the commodity and to regain part of the market lost to synthetic fibers. Composites, is one such area where bountiful opportunities are available for natural fibers to excel.

Composites, the wonder materials are becoming an essential part of today's materials due to the advantages such as low weight, corrosion resistance, high fatigue strength, and faster assembly. They are extensively used as materials in making aircraft structures, electronic packaging to medical equipment, and space vehicle to home building [3]. They are made by amalgamating the separate materials in such a way that resultant materials having bulk properties notably different from those of any of the constituents. Most composites consist of a bulk material (matrix) and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix [4]. The commonly and widely used reinforcement materials are man-made fibres i.e. glass fibre, carbon fibre etc. embedded in polymer matrix system. The reason for excessive utilization of these fibers lies in their excellent mechanical performance and ease of processing. However, their life cycle performance is very dubious. They are extracted from finite petroleum resources, consume huge energy during manufacturing, price high and at disposal stage disturb the environmental hygiene. But in the current scenario due to strong regulations and criteria for cleaner and safer environment, there is a trend of valuing materials which are of low cost and concerned with aspects of being renewable, biodegradable and recyclable.

Jute fibre has some unique physical properties like high tenacity, bulkiness, sound & heat insulation property, low thermal conductivity, antistatic property etc. suited for the manufacture of non-textile products such as fiber reinforced

polymer composites. Fibres can provide reinforcement in polymer matrix in different forms and structures. One of the most economical techniques of using the fibre inside a polymer matrix is using of “Textile Preforms”. Textile preforms are structures made from fibre strands using different traditional textile technique and machinery. This is the most effective way of handling fibres without any distortions before impregnation in resin [5]. The present work is concentrated in processing a composite material from carded jute sliver with different weight percentages and non-woven jute mat as reinforcements with thermoset polymer through hand lay-up technique. The prepared material is subjected to thermal analysis with the help of thermal gravimetric analyzer to make some observations on the addition of jute preforms such that the research findings can lead to the expansion of jute fibers for diverse technical applications. The physical and morphological properties of the same composites have been discussed in earlier published work [6].

## EXPERIMENTAL DETAILS

### 2.1. Materials

Raw jute fibres were procured from Basu Jutex Pvt. Ltd., Kolkata (India) at an expense of Rs.70/kg. Thermoset epoxy resin Araldite CY-230 and hardener HY-951, purchased from M/s CIBATUL Limited, Mumbai (India) were used as the matrix system to produce natural fiber reinforced composites.

### 2.2. Processing and treatment of fibres

The bales of raw jute fiber (Figure 1 a) were opened and washed to remove peripheral impurities adhere to it and treated with 1% NaOH solution for one hour at room temperature to improve mechanical properties. After this, the fibres were washed several times with distilled water to remove any NaOH traces from the surface of the fibres. Finally, the fibres were dried at room temperature for 24 hours. The length of dried fibers were then cut to smaller length (3 inch) and later passed through carding machine to parallelize the entangled mass of jute fibers to more uniform web (Figure 1 b). Nonwoven mat was prepared by thermal bonding technique using low melt bi-component fiber as bonding medium (Figure 1 c).



### 2.3 Composite fabrication

The jute fibre reinforced polymer matrix composites were fabricated by using hand lay-up technique. Thermoset epoxy resin Araldite CY-230 and hardener HY-951 were used as the matrix system. Jute fibers (carded form) and jute thermo-bonded nonwoven mat were used as reinforcement media with epoxy resin as the matrix material. Total three types of composite samples were casted with selected reinforcement type. The code designation of the composites developed for this study is given in Table 1.

The mold of (160x160x10) mm<sup>3</sup> was made for casting the composites. The calculated amount of fibers and the nonwoven mat cut in necessary dimension were dried at 80°C for one hour to remove the moisture from the textile preforms before casting. The accurate amount of epoxy resin was pre-heated to the temperature of 90 ± 10°C and then allowed to cool down to the temperature of 40°C. At this temperature the hardener (10% by weight of resin) was added and stirred thoroughly to minimize air entrapment. The mixture was then immediately used for casting. At first to assure easy release of composites, mold release gel was uniformly spread over the mold base. Then half of this mixture was poured on the mold base, the layer of fibers was placed over it and gently pressed using paint roller and coated with rest of the resin mixture. Utmost care was taken to avoid formation of air bubbles. The samples were allowed to

cure for about 48 hours at room temperature. Similar procedure was adapted for the preparation of the jute nonwoven mat reinforced polymer composite.

*Table 1 Designation and composition of the composites*

Sl. No.	Designation	Composition
1	JF1	Jute fiber reinforced epoxy resin with 1 wt % fiber loading
2	JF2	Jute fiber reinforced epoxy resin with 2 wt % fiber loading
3	JNM	Jute fiber nonwoven mat (1.71 mm thick, 10.43 g wt.) reinforced epoxy resin

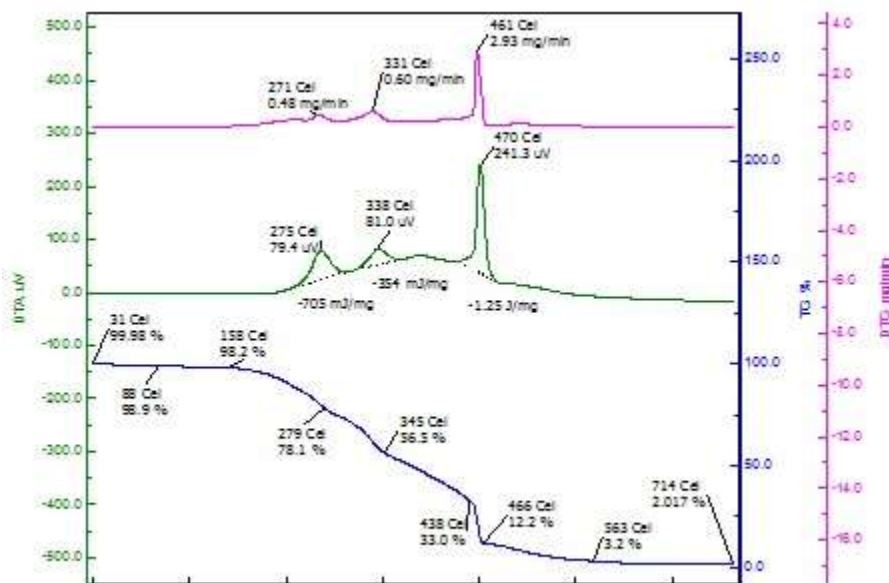
### 2.4 Thermal analysis

Thermal analysis, a branch of materials science studies the properties of materials as they change with temperature. Several methods are generally used that distinguish from one another by the property which is measured. In present work, thermal analysis of the specimens was conducted at Institute Instrumentation Centre, IIT, Roorkee. For thermal analysis the samples were crushed in powder form and mixed with alumina powder (the reference material) in equal amount. Thermo gravimetric analysis was performed under nitrogen atmosphere. The composite samples were heated from room temperature to 700°C at a heating rate of 10°C/min and a nitrogen gas flow rate of 50 ml/min. The thermal gravimetric and derivative thermo gravimetric curve was obtained using TA analysis software.

## RESULTS AND DISCUSSION

### 3.1 Thermal analysis

Figure 2 shows result of thermogravimetric analysis of 1 wt% of jute fiber reinforced composite. Decomposition of this biocomposite was accomplished under three stages ranging from 271 to 461°C with corresponding rate of decompositions ranging 0.48 to 2.93 mg/min. Prior to 160°C, the slight weight loss of 1.78% may be attributed to the eviction of the moisture and low molecular mass biomolecules associated with 1 wt% of fiber reinforcement.



*Fig 2 DTA-DTG-IG of 1 wt% jute fiber reinforced polymer*

The maximum rate of decomposition of 2.93 mg/min was observed at 461°C. Such decomposition has been supported with a high heat of fusion – 1.25 J/mg in the temperature 470°C with DTA signal 241.3 μV. The ultimate decomposition of this composite happened at 560°C leaving char residue 3.2%.

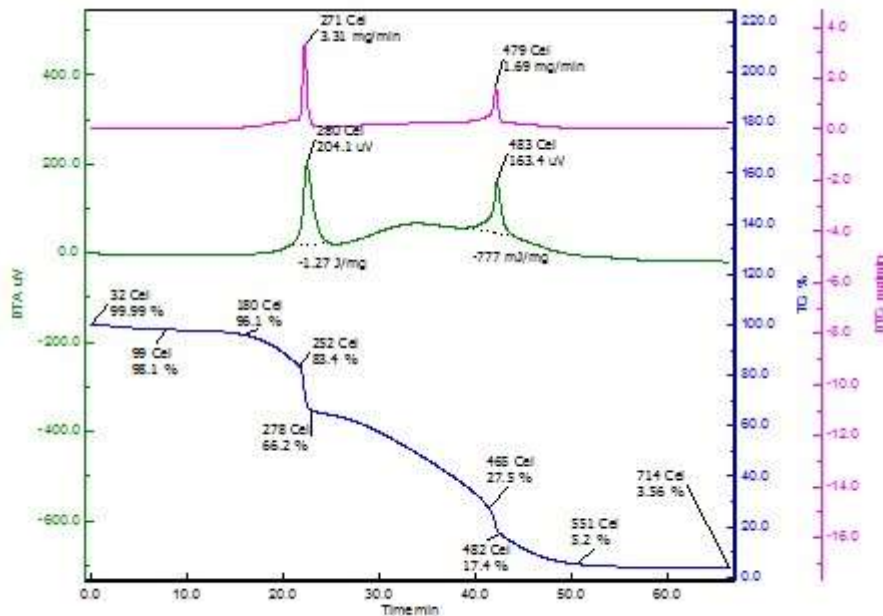


Fig 3 DIA-DTG-TG of 2 wt% jute fiber reinforced polymer

Increase in amount of the filler material i.e. carded jute fiber to 2 wt% contributed a slight modification in the thermal stability of the composite (Fig. 3). Decomposition profile of 2 wt% of jute fiber reinforced composites involved two step degradation ranging 271 to 479°C with rate of degradation 3.31 to 1.69 mg/min. This has rendered maximum rate of decomposition 3.31 mg/min at 271°C. A broad DTA representing the heat of fusion of  $-1.27 \text{ J/mg}$  of the 2 wt% of jute fiber reinforced composite appeared at temperature 280°C with DTA signal 204.1  $\mu\text{V}$ . Prior to 180°C, the weight loss of 3.89% may be assigned to the loss of moisture and low molecular mass biomolecules. The decomposition of composite ceased at 714°C leaving char residue 3.56%. The similar result where addition of coconut fiber improved thermal stability of epoxy based almond shell particle reinforced biocomposite has been reported earlier [7].

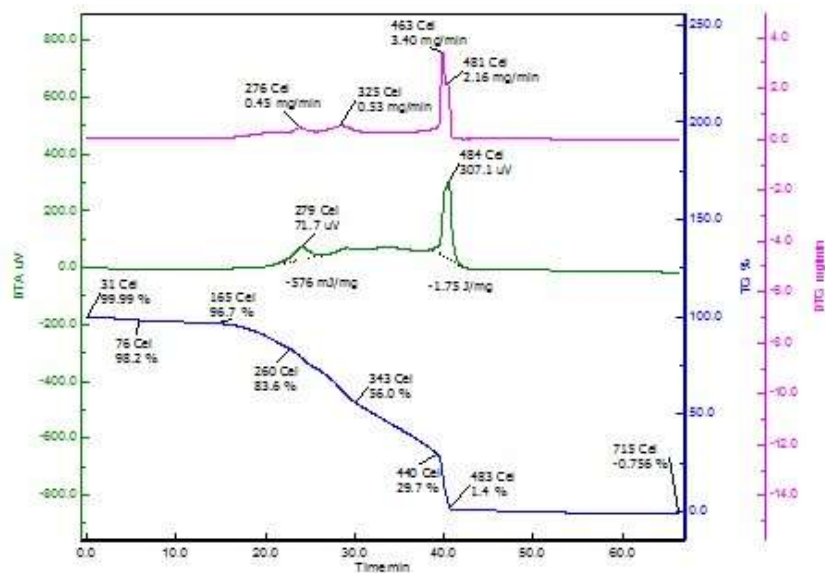


Fig 4 DIA-DTG-TG of jute mat reinforced polymer composites

It can be seen from Fig. 4 that the change in reinforcement form rendered the composite with four step decompositions ranging 276 to 481°C with rate of decomposition ranging from 0.45 to 1.26 mg/min. This has been supported with a DTA peak temperature of 484°C at 307.1  $\mu$ V and a heat of fusion of  $-1.75$  J/mg. Prior to 165°C, the weight loss of 3.29% associated with biocomposite may be assigned to the loss of moisture and low molecular mass biomolecules. Decomposition of the composite ended at 500°C leaving char residue 0.95%.

## CONCLUSION

Composite specimens containing nonwoven jute mat and alkali treated short jute fibers with different weight percentages (1, 2 wt%) were subjected to thermal degradation by means of Thermo Gravimetric Analysis (TGA). From this study, it can be concluded that increase in percentage of jute fiber has improved final residue and the maximum degradation temperature of composite and the thermal stability of the composite has been upgraded. Jute mat reinforced composite showed least thermal stability and final residue at temperature above 480°C. This may be attributable to the presence of low melt fiber used during the jute mat preparation.

## ACKNOWLEDGEMENT:

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