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An Investigation of Thermal Properties of Reinforced Coconut Coir-Bagasse Fibres Polymer Hybrid Composites

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ABSTRACT

Increasing concern about environment has made scientist and engineers very eager in their search for environmental friendly materials. So lot of research is going on today in the field of material science to develop newer materials. Natural fibres are getting much attention of researchers, engineers and scientists as reinforcement in the epoxy matrix to develop natural fibre reinforced epoxy composites. In the present work an attempt has been made to develop a systematic approach to evaluate and study the effect of process parameters on Thermal Analysis of coir and bagasse fiber reinforced epoxy based hybrid composites. The composite panel was fabricated usinghand lay-up method to the size of 300mmx200mmx10mm with various weight percentage of natural fibers namely coconut coir (5 wt %) and bagasse (45 wt %) combined with epoxy resin. The mechanical properties testing such as tensile, flexural and impact strength were carried out for the samples cut from the fabricated composite panel to the dimensions as per ASTM standard.

Keywords: Natural Fibres, ASTM, Coir Fiber, Micrometer, Fabrication, DSC, PERKIN-ELMER, TGA

I. INTRODUCTION

Composites made of conventional fibres (glass, carbon, graphite, boron, Kevlar etc.) have a high cost. If made of inexpensive fibres, they will cut-down the cost of components for which they are used. They are light weight and possess high specific strength and are eco-friendly too. [1] Increasing concern about global warming and depleting petroleum reserve have made scientists focus more on the use of natural fibers such as bagasse, coir ,sisal, jute etc. as reinforcement materials in composites [2]There are enormous mechanical advantages for using composite materials. Natural Fibre Composite (JFRC) illustrates the specific properties benefits of the composites structural use over traditional industrial materials. [3] Coir is the natural fibre of the coconut husk where it is a thick and coarse but durable fibre. It is relatively water-proof and has resistant to damage by salt water and microbial degradation [4]

Coir Fiber: Coir (Cocas nucifera) is obtained from the husk of the fruit of coconut palm. Coir fibers are located in between the husk and outer shell of the coconut. Thefibers are made up of small threads ranging from 0.03-0.1 cm long andabout 12-24 micrometer in diameter. They are narrow and hollow with thick walls made of cellulose. The fiberishydrophilic in nature and has high corrosive resistance against salt water. It is used in products such as doormats, brushes,mattresses etc [5] Coconut Coir is a lingo-cellulosic natural fiber. It is a seed-hair fiber obtained from the outer shell, or husk, of the coconut, the fruit of Cocos-nucifera. The oarse, stiff, reddish brown fiber is made up of smaller threads, each about 0.03 to 0.1 cm long and 12 to 24 micrometer in diameter; coir is composed of lignin, a woody plant substance, and cellulose. The individual fiber cells are narrow and hollow, with thick walls made of cellulose. Mature brown coir fibers contain more lignin and less cellulose than fibers such as flax and cotton and are thus stronger but less flexible. The coir fiber is relatively waterproof and is the only natural fiber resistant to damage by salt water. The fibrous layer of the fruit is separated from the hard shell manually by driving the fruit down onto a spike to split it (de-husking).[6]. Sugarcane bagasse is a plentiful lignocellulosic waste typically found in tropical countries that process sugarcane, such as Brazil, India, Cuba, and China. It is called bagasse or cane-chuff, and it is obtained as a left-over matter after liquor extraction in a sugar factory. About 54 million tons of bagasse is produced annually throughout the world. In general, sugar factories generate approximately 270 kg of bagasse (50% moisture) per metric ton of sugarcane. Bagasse fiber bundles are unusually coarse and stiff material. It is used either as a fuel for the boilers by the sugar factory or as a raw material for the manufacture of pulp and paper products, various types of building boards, and certain chemicals. It is suitable for making non-woven products. The chemical compositions of pure bagasse fiber bundles are cellulose (52.42%), lignin (21.69%), hemicelluloses (25.8%), ash (2.73%), and ethanol/dichloro methane extract (1.66%) [6].Several studies have been carried out to understand the structure, mechanical properties, and the effect of chemical modification on bagasse fiber bundles. However, the traditional uses of bagasse husk consume only a small percentage of the potential total world production of bagasse husk. Hence, research and development efforts have been underway to find new applications for bagasse, including utilization of bagasse as reinforcement in polymer composites.[7]

In tropical and equatorial countries, fibrous plants such as banana, oil palm, bamboo, sugarcane, etc. are available in abundance and fibres like sugarcane and appear to have a considerable interest as reinforcement in polymer matrices for low-cost composites. They are widely used in the production of bearing components used in automobile industries such as gears, wheels, bushes etc. in which friction and wear are critical issues[8]The sugar cane bagasse is a residue widely generated in high proportions in the agro-industry. It is a fibrous residue of cane stalks left over after the crushing and extraction of juice from the sugar cane. Bagasse is generally gray-yellow to pale green in colour. It is bulky and quite non uniform in particle size. The sugar cane residue bagasse is an underutilized, renewable agricultural material.[9]Moreover, natural fibres like banana, sisal, hemp andflax, jute, coconut, sponges, bamboo, wood dusts and oil palm have attracted scientists and technologists for applications in consumer goods, low-cost housing and other civil structures. A number of investigations have also been conducted on several types of natural fibres to study the effect of these fibres on the mechanical properties of polyester matrix composite materials.[10] Manufacturing of hybrid Composite material using natural fibre is widely used now a day in many industries. It is shows improved mechanical as well as thermal properties. Use of bagasse as a fiber and coconut coir in particulate form as a reinforcement with thermosetting polymer (epoxy) is very economical and eco-friendly also. bagasse and coconut coir are treated as solid waste. Every year Billions of tonnage of of bagasse and coconut coir is produced from agricultural waste. The only method available to discard this waste is using as a fuel etc. If we use of bagasse and coconut coir as reinforcement with thermosetting/thermoplast polymer which shows better mechanical and thermal property. A huge amount waste of bagasse and coconut coir can be utilized for producing such type of composite material.

II. METHODS AND MATERIAL

Fabrication

Take a prepared Mould of Dimension 550×350 mm weighing 45 kg. Clean both the inner surfaces with the help of brush to remove dirt and other impurities. Place and 0.2 mm thick Transparent Sheet of plastic at the Lower surface of the Mould .Wax is applied on the top surface of the transparent sheet. Prepare two wooden frame (300×200×5)mm each Place pre-prepared frame (wood) of dimension (300×200×5)mm over the sheet. Fill the frame with matrix (resin mixed with coconut coir particulate) Place bagasse longitudinally over the mixture. Now place another frame over the bagasse fibre. Again fill the frame with matrix (resin mixed with coconut coir particulate). Now place the upper part of the mould over the transparent sheet. Leave the composite for curing for approximately 24 hours at room temp. After 24 hours the sheet is removed from the mould. After removing the sheet the wooden frame is removed with the help of a wooden cutter. Now thecomposite sheet of dimension (280×180×10) mm is obtained which can be further tested.

Now the composite sheet of dimension (300×200×10) mm is prepared which can be characterised by DSC, TGA and water absorbtion test. Specimen were cut with the help of diamond tip hand cutter.

Figure 1. Mould

Figure 2. Baggase Fibre

Figure 3. Dried Baggase Fibre

Figure 4. Chopped coconut fibre

Figure 5. Final Sheet

III. RESULTS AND DISCUSSION

A. Differential Scanning Calorimetry (DSC)

Differential scanning calorimetry or DSC is a thermo analytical technique in which the difference in the amount of heat required to increase the temperature of a sample and reference is measured as a function of temperature. Both the sample and reference are maintained at nearly the same temperature throughout the experiment. Generally, the temperature program for a DSC analysis is designed such that the sample holder temperature increases linearly as a function of time. The reference sample should have a well-defined heat capacity over the range of temperatures to be scanned.

Glass Transition Temperature-T_g

The Glass Transition Temperature (T_g) is one of the most important properties of any epoxy and is the temperature region where the polymer transitions from a hard, glassy material to a soft, rubbery material. As epoxies are thermosetting materials and chemically cross-link during the curing process, the final cured epoxy material does not melt or reflow when heated (unlike thermoplastic materials), but undergoes a slight softening (phase change) at elevated temperatures.

DSC for Epoxy

DSC test is performed on the plain epoxy and Tg temperature is found to be 155^0C. This value of Tg Temperature is obtained by PERKIN-ELMER thermal analysis method. Hold for 1 min. at 50^0C and heat from 50^0C to 300^0C at 20^0C /min. In this analysis the graph is drawn between Heat Flow Endo Up (on y-axis) and Temperature (on x-axis). And the value of Tg is obtained by tangent method.

DSC Test Result

TheValueofTg(GlasstransitionTemperature) for plain epo155^0

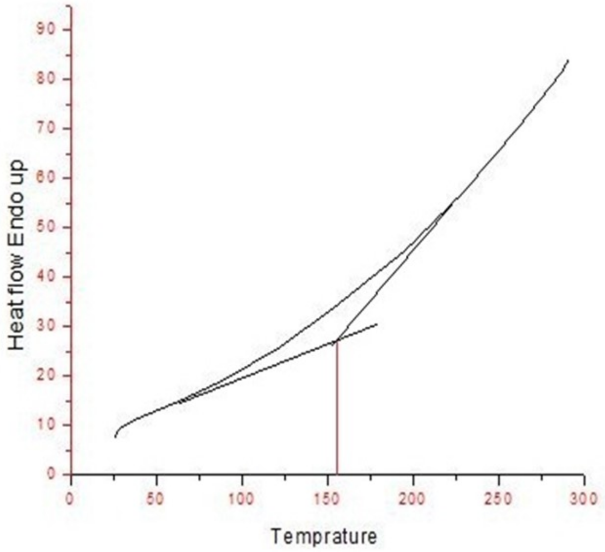


Figure 6. DSC for Epoxy

DSC for Hybrid Composite material

DSC test is performed on the hybrid composite and Tg temperature is found to be 210^{0}C. This value of Tg Temperature is obtained by PERKIN-ELMER thermal analysis method. Hold for 1 min. at 50^{0}C and heat from 50^{0}C to 300^{0}C at 20^{0}C /min. In this analysis the graph is drawn between Heat Flow Endo Up (on y-axis) and Temperature (on x-axis). And the value of Tg is obtained by tangent method.

The Value of Tg (Glass transition Temperature) for Hybrid Composite material is 190^{0}C

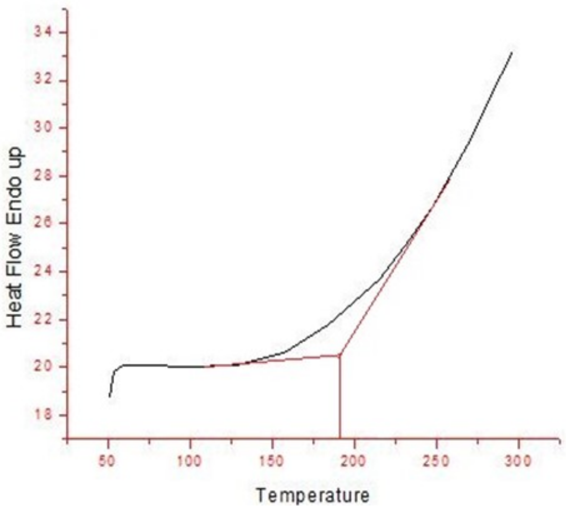


Figure 7. DSC for Hybrid Composite material

Summary of DSC Test Result

Table 1 : Summary of DSC Test Result

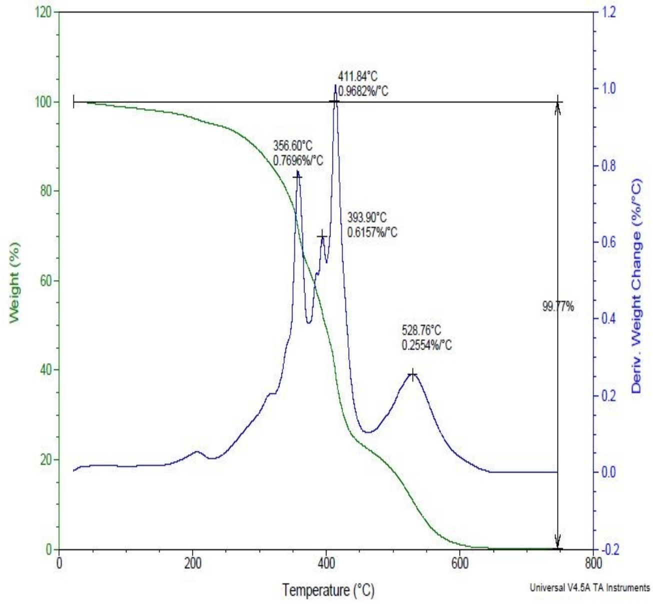
S.No.	Material	Tg (Glass transition Temperature)
1	Epoxy	155^{0}C
2	Hybrid composite	190^{0}C

Conclusion from DSC test

From the above result we conclude that the glass transition temperature (Tg) of hybrid composite increases as compared to plain epoxy. The bagasse as a fiber and Coconut coir as particulate form are aided to plain epoxy enhanced the glass transition temperature (Tg) is up to 190^{0}c.

B. TGA Test

Thermo gravimetric analysis or thermal gravimetric analysis (TGA) is a method of thermal analysis in which changes in physical and chemical properties of materials are measured as a function of increasing temperature (with constant heating rate), or as a function of time (with constant temperature and/or constant mass loss)



. **Figure 8.** TGA for hybrid composite

Conclusion from TGA TGA test-Curve of hybrid composite as shown in Figure 4.6 Thermal treatment covered of bagasse fiber& coconut coir hybrid composite gave an initial weight loss below150^{0}C.due to loss of moisture. The weight loss observed with composite at this reason might be due to the molecular weight of the compounds. The initial weight loss is due to complex secondary reaction and formation of volatile product.

From above Figure shows, it is obvious that no degradation occurred until 100^{0}C for the sample the onset being above 150^{0}C.The maximum rate of weight loss was observed in the range of 150^{0}C.– 600^{0}C. The amount of residue left is 0.33%.

From the thermograms it is apparent that sample undergoes a two-step degradation process .The first stage, thermal degradation process occurred in the temperature range of 150^{0}C.-350^{0}C. .The second stage degradation in the temperature range of 400^{0}C.-600^{0}C.And may be due to the compound decomposition of fibre and matrix.

The significant thermal behaviour of the compound was determined from the initial degradation temperature which is taken as the temperature at which degradations started and the residue weight percentage denoted as char.

Initial degradation temperature was 150^{0}C and final degradation temperature was 600^{0}C.

C. Water Absorption Test

Water absorption test conducted in which specimen is immerged in the for 36 hours at room temperature under normal condition and each 4hours their weight would be measured .

A rectangular test piece of dimension (60mm×40mm×10mm) was dipped in a glass containing water 250ml for 36 hrs. Initial weight of the specimen was 25 g measured by the weighing balance (manufactured by Ohaus) whose least count is 0.01g. The weight of the specimen was measured at a time interval of 6 hrs till 36 hrs. the specimen absorbed water only upto 24 hrs. The specimen weight increased upto 0.55g in 24 hrs only and after that the specimen weight shows that there is no increase in weight that is specimen weight is constant.

After 24 hrs, the samples were taken out from the moistenvironment and all surface moisture was removed with the help of a clean dry cloth or tissue paper.

Figure 9. Water Absorption Test

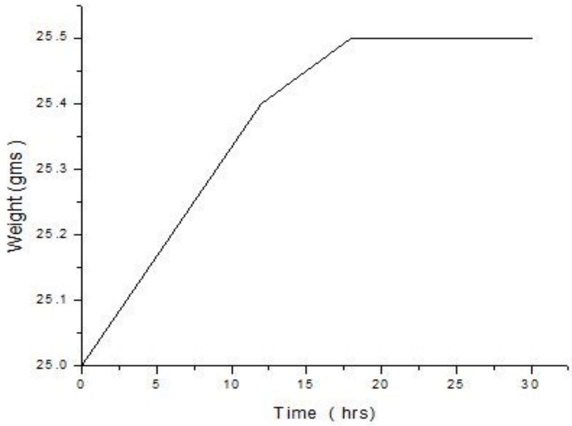


Figure 10. Graph of Water Absorption Test

IV. CONCLUSION

The present investigation a hybrid composite (bagasse and coconut coir) is made with polymer matrix (Epoxy Resin). Thermal Tests are conducted and shows.

1. Initial degradation temperature of hybrid composite was 1500C and final degradation temperature was 6000C. The maximum rate of weight loss was observed in the range of 1500C – 6000C. The amount of residue left is 0.33%.
2. The glass transition temperature (Tg) of hybrid composite increases as compared to plain epoxy. The bagasse as a fiber and Coconut coir as particulate form are aided to plain epoxy enhanced the glass transition temperature (Tg) is up to 1900c.
3. Natural fiber reinforced hybrid composite material can be used in smart structure, Wall ceiling, automobile interior and in packaging industry.

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