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Investigation of Thermal Properties of Borassus Flabillifer Fruit and Sisal Fiber Composite Material with Addition of Nano Carbon

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Abstract: **-- The main objective of this paper is to investigate the effect of Nanocarbon on thermal properties of borassus fruit and sisal natural fiber reinforced composites .The composites with and without Nano carbon have been prepared by incorporating 100% biodegradable fiber reinforcement . The primary derivative thermo grams of the fibers were recorded in an inert atmosphere at the heating rate of 20 ^{o}C/min. The thermal properties of these samples were investigated according to ASTM standard. From the result it was absorbed that the borassus fruit and sisal composite with addition of Nano carbon showed that there is an appreciable increase in thermal properties of the sample when compared to without addition of Nano carbon composite.**

Index Terms: **-- Borassus fruit fiber, sisal fiber, multi-wall carbon Nanotubes, matrix, thermal conductivity, specific heat capacity, guarded heat flow meter, differential scanning calorimeter.**

I. INTRODUCTION

Natural fibers have played a very significant role in human civilization since prehistoric times. The natural fibers are completely biodegradable and can be used as reinforcement in the development of green composites. The advantages of natural fiber are low-cost, low density, acceptable specific strength; less tool wears biodegradability, co friendly and renewability. Therefore, research in the field using natural fibers has attracted much attention in the composite materials.

Several investigators worked on mechanical and thermal properties of natural fibers such as sisal, borassus, hemp, coir, kenaf and jute reinforced composites. The borassus fiber is abundantly available in the nature. It is a genius of six specious of fan palms, native to tropical regions of Africa , India ,Asia and New guinea .They are growing up to 30meters height and 2-3m long leaves. The flowers are small in density clustered spikes, followed by large brown roundish fruits. The sisal fiber which comes from Agave Sisalana of Agave family .The sisal fiber is used in making twine and ropes. The sisal fibers have high tensile strength, light weight, biodegradable and abundantly available.

A carbon Nanotubes is a tube shaped material made of carbon, having diameter measuring on the nanometer scale .A Nanometer is 1billion of a meter or about one ten thousand of the thickness of a human hair. The addition of Nano carbon material to natural composite had the advantages of being light, strong, cheap, nonabrasive, high specific mechanical and thermal properties. Carbon Nano fibers and Nanotubes are promising to several fields in material science and are a major component of Nanotechnology. Nanotubes have a wide range of unexplored potential application in various technological areas such as aero space, automobiles, medicine chemical industries etc.

Composite materials consist of two or more constituents with physically separable phases. However, a materials system collection of two or more physically distinct phases whose mixture produces aggregate properties that is different from those of its constituent's. Composite material that comprise strong load carrying material imbedded in weaker material. The two or more dissimilar material can be combined and form a composite material which provides high strength, rigidity but keep their identities and properties. When the fiber reinforced composite consist of several layers with different fiber orientations called the laminate composite or multilayer composite.

The present research we have characterized the behaviour of thermal properties of borassus and sisal fiber composite with and without addition of Nano carbon material. In many applications, particularly in automotive industries components were subjected to mechanical as well as thermal layers. A considerable amount of literature is available on thermal behaviour of natural fiber reinforced composites .However; little information is available on

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thermo physical properties of natural fiber reinforced composites over and above room temperature. Thermo physical properties such as thermal conductivity, thermal diffusivity, and specific heat capacity of natural composites were studied. Therefore, the focus of the work is to investigate the behaviour of thermal properties of borassus and sisal fiber composite with and without addition of Nano carbon material was found out experimentally.

II. MATERIALS & METHODS

A. *Matrix*

Epoxy is a thermosetting polymer that cures (polymerizes& cross links) when mixed with a hardener. Epoxy resin of the grade LM-556 with a density of 1.1-1.5g/cm^3 was used in this research. The hardener HV-9.51 was used to fabricate the composite. The matrix material was prepared with the mixture of epoxy and hardener at a ratio of 10:1.

B. *Sisal fiber*

Sisal is a natural fiber (scientific name is Agave sisalana) of Agavaceae (Agave) family yields a stiff fiber used in making twine & rope. Sisal fiber is one of the renewable resources in the nature and fully bio-degradable. The sisal fiber is exceptionally durable and with minimal wear & tear. It is extracted by a process known as decortications, where leaves are crushed & beaten by a rotating wheel set with blunt knifes, so that only fibers will remain.

C. *Borassus Fruit Fiber*

Borassus is a natural fiber (science name is caryotaurens) of Arecaceae family and is used for making strong ropes. The borassus fiber is also having several advantages like strong, more durable, but less pliant and elastic then the coir. The extraction of fibers involves the retting process followed by the decortications. The borassus fruits were taken and immersed in the water tank for two weeks. Then they are taken out from the water and remove the outer shells of the fruits and the fibers were stripped from the stalks by hand, washed and dried in the sun. After drying, any extraneous matter that may still be adhering to them was removed.

D. *Fiber surface treatment*

Washed and dried sisal fiber and borassus fruit fiber were taken in separate trays; to these trays 10% NaOH solution was added. Then the fibers were soaked in the solution for 10hours. After that the fibers were washed thoroughly with water to remove excess of NaOH sticking to the fibers.

E. *Preparation of Specimen*

A GI sheet mounding is used for making the sample as per ASTM standards with required dimensions. Then the mould sheet is coated with a mould releasing agent for the easy removal of the sample. After that the resin and hardener is mixed with the ratio of 10:1 respectively. Before mixing of resin and hardener, the Nano carbon tubes were mixed with the hardener and stirring for proper mixing. Then the pre-calculated amount of hardener is mixed with epoxy resin and stirred for 20 minutes before pouring into the mould. The hand layup technique is used to impregnate the composite structure. A stack of sisal and borassus fibers were carefully arranged in a unidirectional manner and then the epoxy resin with hardener is pouring on the fiber or coating on the fiber slowly. The remaining mixture is completely poured up on the surface of the fibers. The brush and roller is used to impregnate fibers and after that close the glass sheet. The mould was kept under pressure for 24 hours at room temperature The test specimens of required size were cut out from the composite manufactured after curing. The five identical test specimens were prepared for each test and subjected to each test.

III. THERMAL PROPERTIES TESTS

A. *Thermal Conductivity :*

Thermal conductivity of a material depends on the nature of material, the area of cross section normal to the direction of heat flow and the temperature gradient between the hotter part and colder part of the material. The guarded heat flow meter test method is used to determine the thermal conductivity of the samples at different temperature using Unitherm model 2022 instruments in accordance with ASTM-E-1530.

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B. *Specific Heat Capacity:*

It is one of the most important thermo dynamic a property of the engineering material. The specific heat capacity is independent of the mass and shape of the material. The variation in specific heat values of samples with respective temperature .The specific heat capacity of samples is measured by using Differential Scanning Calorimeter (TA INSTRUMENTS, MODEL NO Q20) at the heating rate of 20^0C /minute.

IV. RESULTS AND DICUSSIONS:

Table: 1. Thermal properties of sisal and borassus fruit fiber composite without NANO carbon

Temperature ^{0}C	Thermal conductivity (W/m.K)	Specific heat capacity (kJ/kg.K)
30	0.154	1.229
60	0.167	2.554
90	0.183	2.826

Table: 2. Thermal properties of sisal and borassus fruit fiber composite with NANO carbon

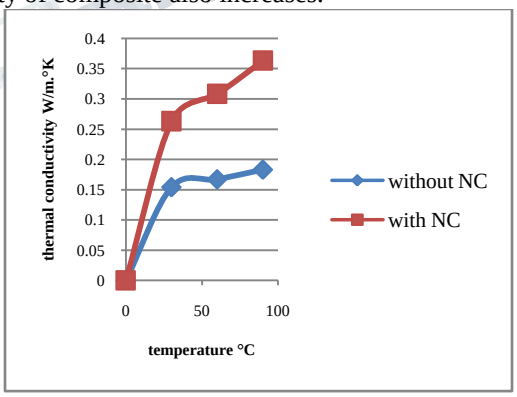
Temperature ^{0}C	Thermal conductivity (W/m.K)	Specific heat capacity (kJ/kg.K)
30	0.263	2.328
60	0.308	3.281
90	0.363	4.356

The results shows that the borassus and sisal fibers can be used as reinforcement. The thermal conductivity, specific heat capacity were measured with addition of Nano carbon and without addition of Nano carbon and then reported in the above tables. Table (1) reveals that the composite without addition of Nano carbon is exhibiting low thermal conductivity and specific heat capacity. Table (2) reveals that the composite material with addition of Nano carbon of all the measured samples of thermal properties increased gradually with respective temperature. The result reveals that sisal and borassus fruit fiber composite with Nano carbon have as a thermal insulating reinforcement component in the development of insulating green composites.

V. THEORITICAL DISCUSSION:

More recently the fiber reinforced composite with Nano carbon have high strength, being light, nonabrasive, high thermal conductivity and dimensional stability. It is important in weight sensitive applications such as aircraft and space vehicle, energy saving in conduction with automobile air conditioning as become more important. The main application of this material used as a building insulation to maintain acceptable temperature in building (by heating and cooling) uses large proportional global energy consumption. It provides more uniform temperature throughout space inside the buildings. It is hoped that it the material is commercialized the cost of sisal and borassus fruit fiber at much cheaper price than the glass fibers so the overall cost of the materials will be less than the present composite material MS sheet or Aluminium.

From the graph-1, it indicates the variation of thermal conductivity of composite material with and without Nano carbon. It is observed from the graph that thermal conductivity is increasing with respect to temperature. From the result the thermal conductivity of composite with Nano carbon is higher than the composite without Nano carbon. From graph-2 shows the variation of specific heat capacity of composite material with and without Nano carbon. It is observed from the graph that specific heat capacity of composite is increasing with respect to temperature. It is mainly due to the fact that Nano carbon particle exhibit higher specific heat capacity .As a result of this specific heat capacity of composite also increases.



Graph-1: shows comparison of thermal conductivity of composite with and without Nano carbon.

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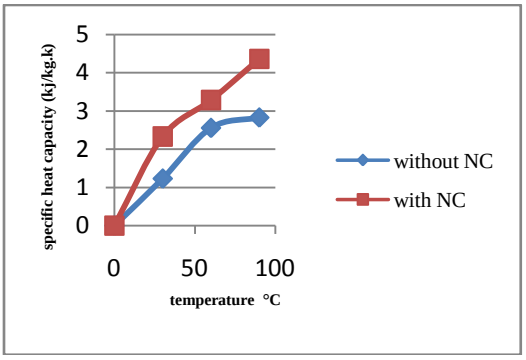

Graph-2: shows comparison of specific heat capacity of composite with and without Nano carbon.

VI. CONCLUSION:

It was observed that the thermal properties of the natural fibers such as thermal conductivity and specific heat capacity are measured with and without addition of Nano carbon material were tested and reported the results in the above table. It shows that the sisal and borassus fruit fibres act as a thermal insulating reinforcement component in development of insulating green composites. Therefore, it was observed that there is an appreciable increase in thermal properties of composite with addition of Nano carbon material. When compared to without addition of Nano carbon material composite.

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