Thermal Properties of Natural Fiber Reinforced Hybrid Composites

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***Abstract* : This project mainly deals with the analysis of moisture absorption effect and the thermal properties of palmyra fiber reinforced epoxy composites. The hybrid composites were prepared using raw and alkali treated Palmyra fiber and glass fibers with epoxy resin and three different compositions by using hand layup technique. Specimens were cut from the fabricated laminate according to the ASTM (American society for Testing & Materials) standards for different experiments. Water absorption studies of Palmyra fiber composites shows that raw fiber absorbed more water than treated fiber. Thermogravimetric analysis (TGA) was used to measure the rate of change in the weight of composites as a function temperature. The TGA of the specimen with alkali treated and untreated fiber shows that T2 composite shows higher thermal stability. The thermal behaviour further characterized by means of differential scanning calorimetric analysis. The Glass transition temperature of the T3 proportion better than the other proportion. Thermal conductivity of the composites were found from various physical models and heat transfer rate of these physical models were analyzed through Ansys.**

Keywords : Palmyra fiber, Glass Fiber, Epoxy resin, Moisture absorption, TGA, DSC, Thermal conductivity

1. INTRODUCTION

The long term vision of this project is to develop composites with reduced thermal stresses to avoid catastrophic failure and creating environmental friendly atmosphere. Many of the polymer composites have glass fiber as reinforcement even the polymers in usage process polluted environment. Since the glass fiber or fabrics are non-degradable property, in recent years the use of natural (lingo-) cellulosic fibers, e.g.: flax, sisal, banana, jute, coir, hemp, has been gaining a noteworthy attention in polymer composites, as an alternative to traditional fibers such as glass, carbon and aramid.

The increasing interest in this material is due to the inherently environmentally friendly nature of natural fibers, leading to carbon dioxide mitigation, their low cost and low density. Other advantages include biodegradability, recyclability and significant processing advantages. In particular, equipment abrasion, energy consumption, and respiratory irritation are all reduced.

Epoxy is widely used in industrial applications, such as adhesive, coatings, electronics and aerospace structure. Due to its excellent mechanical and chemical properties, epoxy is also one of the important materials using as the matrices for FRP. It has low shrinkage upon curing, good chemical resistance. Thermal properties and good performance at elevated temperatures.

It is observed that, some of the natural fibers got degraded thermally, at the melting point of thermoplastics. So it is desirable to study the thermal stability of the natural fibers before they are considered as reinforcement in thermoplastic matrices.

1.1 COMPOSITE MATERIALS

Composite materials are engineered materials made from two or more constituent materials that remain separate and distinct on a macroscopic level while forming a single component. There are two categories of constituent materials: matrix and reinforcement. At least one portion (fraction) of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcement imparts special physical (mechanical and electrical) properties to enhance the matrix properties. Due to the wide variety of matrix and reinforcement materials available, the design potential is incredible.

2. MATERIALS AND EXPERIMENTS

2.1 Extraction of fiber

The matured Borassus fruits were collected from Borassus fruit trees and immersed in water for a week. The flush which was bonded with the fibers absorb water and the retting of the same started. The flush lost its bonding strength at this stage. Now the fruits were taken out of water and thoroughly washed in running water. During the washing process the fruits were gently pressed for the removal of the retted flush. The fruits were then immersed in water for three days and the process was repeated for the re- moval of remaining flush. The fibers were taken out and allowed to dry in the shadow for a couple of days. The fibers were then dried in sunlight for half an hour and extracted. The fibers were gently rammed to remove the unwanted short fibers and dry flush particulates from them.

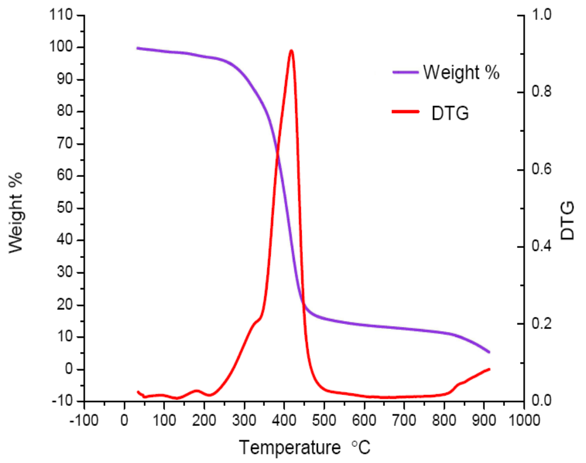
2.1 Alkali treatment of fibers

The dry Borassus fruit fibers were treated with 5%, 10% and 15% NaOH solution separately for about 0.5 h at room temperature. The fibers were then washed with fresh water to take away any NaOH sticking on the fiber surface. The fibers were neutralized with 2.5% HCl solution at room temperature. The fibers were again washed in distilled water and dried at room temperature for 24 h. The 5%, 10% and 15% NaOH alkali treated.

3. THERMOGRAVIMETRIC ANALYSIS

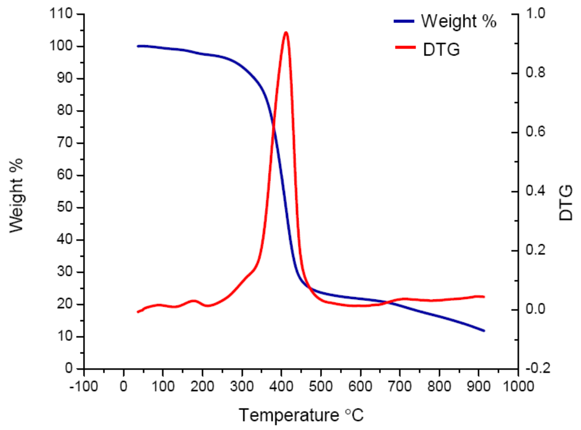
A thermal gravimetric analyser ,TGA 7 (Perkin Elmer),Q500 Hi-Res TGA was used to investigate the thermal stability of the composites.The samples (5-30 mg) were heated from 50 °C to 950 °C under nitrogen environment at a heating rate of 20 °C/min.

3.1.1 Thermogravimetic and Derivative Thermogravimetric curve for T1 Compositions



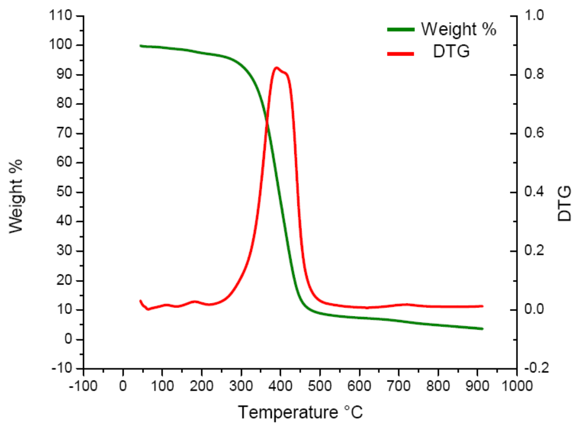
TGA and DTG Curve for T1 Composite

3.1.2 Thermogravimetic and Derivative Thermogravimetric curve for T2 Compositions



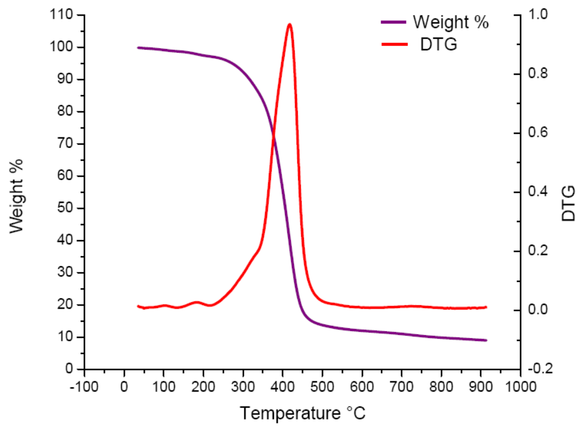
TGA and DTG Curve for T2 Composite

3.1.3 Thermogravimetic and Derivative Thermogravimetric curve for T3 Compositions



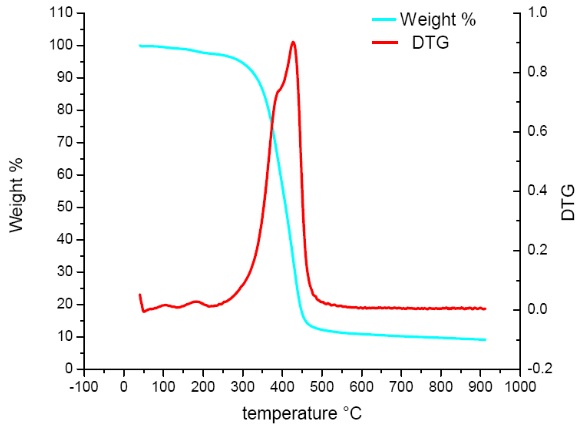
TGA and DTG Curve for T3 Composite

3.1.4 Thermogravimetic and Derivative Thermogravimetric curve for UT1 Compositions



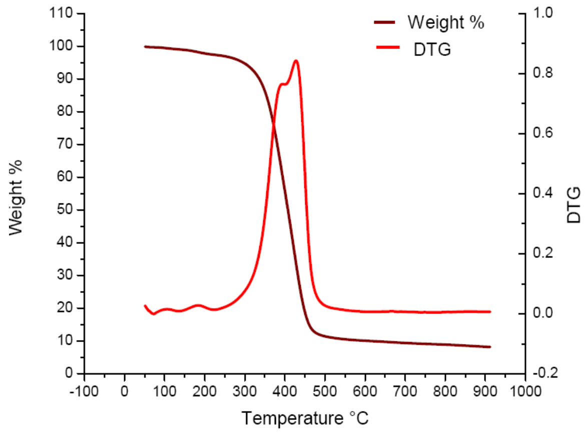
TGA and DTG Curve for UT1 Composite

3.1.5 Thermogravimetic and Derivative Thermogravimetric curve for UT2 Compositions



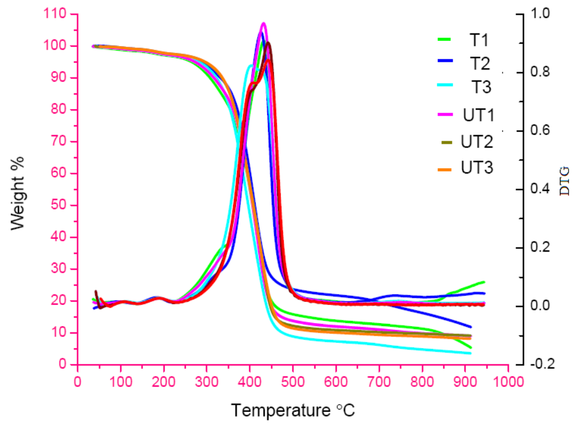
TGA and DTG Curve for UT2 Composite

3.1.6 Thermogravimetic and Derivative Thermogravimetric curve for UT3 Compositions



TGA and DTG Curve for UT3 Composite

3.1.7 Inference from Thermogravimetric Analysis



TGA and DTG Curve for all Specimens

The degradation temperatures at different level of Thermogravimetric weight loss for the composites.

The results of Thermogravimetric analyses for Treated and Untreated Specimens are shown in the figure from 3.1.1 to 3.1.7. The TGA curve of Palmyra hybrid composites at different time intervals gave three distinct temperatures, were the samples experience significant weight loss. The slight weight loss (below 120 °C) is due to release of moisture present in the fiber. Above this temperature, thermal stability is gradually decreasing and decomposition of fiber occurs.

The first stage process Ti (225 °C-250 °C) is the thermal depolymerisation of hemicelluloses, pectin and the cleavage of glycosidic linkage of cellulose (weight loss 20.0%), the final degradation (480 °C - 530 °C) is attributed to the decomposition of the α–cellulose (weight loss 45.2%) whilst the decomposition of lignin takes place in a temperature range .

The maximum weight loss found to be in a inflection point. In Derivative Thermogravimetric curves, the peak indicates the maximum rate of weight loss on the samples (390 °C-430 °C).

5. RESULT AND CONCLUSION

The Thermal behaviour of Palmyra fiber, E-glass fiber, & Epoxy composites were investigated. Six different ratio of Palmyra fiber (Treated and untreated), epoxy-glass fiber, Epoxy resins were used to make the specimens. The Moisture absorption test, Thermogravimetric Analysis, Differential Scanning Calorimetric Analysis were conducted on the specimen and following conclusions were arrived at. The treated palmyra fiber composite absorbed less water than the untreated palmyra fiber Composite.Out of the six specimens the moisture absorption behaviour of T3 specimens has 5-15% less than the other samples.

The moisture absorption behaviour increases with increase of natural fiber content present in the composites.The initial and final degradation temperature of palmyra fiber composites were measured in the temperature range 225 °C – 530 °C. From these values it can be concluded that the thermal stability of fibers was improved by alkaline treatment.The thermal stability of the T2 composite specimens has better than the other composite Specimens.The degradation temperature range was reduced with the increase of natural fiber content present in the composites.The glass transition temperature of the composites was found from 57.4 °C to 69.6 °C. The glass transition temperature of T3 specimen was found better than the other Specimens.From the Thermal conductivity values, addition of natural fibers reduces the thermal conductivity.

REFERENCES

[1] Athijayamani.A, hiruchitrambalam.M, Natarajan.U, Pazhanivel.B (2009). 'Effect of moisture absorption on the mechanical properties of randomly oriented natural fibers/Polyester hybrid composite', Material science and Engineering A 517, pp .344-353.

[2] Alavez-Ramirez.R, Chinas-Castillo.F, Morales-Dominguez.V.J, Ortiz-Guzman (2012). 'Thermal conductivity of coconut fiber filled ferrocement sandwich Panels', Construction and building materials Vol .37, pp. 425-431.

[3] ASTM Standard: D 570-98. 'Test Methods for Water Absorption of Plastics', In ASTM standards, Vol. 08.01, New York, NY: American Society for Testing and Materials.

[4] ASTM Standard: D 6370-99. 'Standard Test Methods for Polymer Compositional analysis by Thermogravimetry', In ASTM standards, Vol. 09.01, New York, NY: American Society for Testing and Materials.

[5] ASTM Standard: D 3418-12e1. 'Standard Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetric', In ASTM standards, Vol. 08.02, New York, NY: American Society for Testing and Materials.

[6] Bakare I.O, Okieimen F.E, Pavithran.C, Abdul khalil.H.P.S, Brahmakumar.M. (2010) 'Mechanical and Thermal properties of sisal fiber-reinforced rubber seed oil-based polyurethane composites'. Materials and design Vol. 31. pp.4274-4280.

[7] Hazizan Md akil, Leong Wei Cheng,Mohd Ishak Z.A, Abu baker.A, Abd Rahman.M.A. (2009). 'Water absorption study on pultruted jute fiber reinforced unsaturated polyester composites'. Composite science and technology Vol.69, pp.1942-1948.

[8] Hongyan Chen, Menghe Miao, Xin Ding (2009). 'Influence of moisture absorption on the interfacial strength of bamboo/Vinyl Easter composites'. Composites: Part A. pp.2013-2019.

[9] Morsyleide F.Rosa, Bor-sen chiou, Eliton S.Medeiros, Delilah F.Wood, Tina G.Williams, Luiz H.C. Mattoso (2009) . 'Effect of fiber treatments on tensile and thermal properties of starch/ethylene vinyl alcohol copolymers/coir biocomposites'. Bioresources Technology Vol 100. Pp. 5196-5202.

[10] Maries Idicula,Abderrahim Boudenne, L.Umadevi and Laurent Ibos (2009). 'Thermo physical properties of natural fiber reinforced

polyester composite'. Composite science and Technology Vol.66. pp.2719-2725.
[11] Mounika.M,Ramaniah.K, ratna Prasad.A.V, Mohana Rao.K (2012). 'Thermal conductivity Characterization of Bamboo Fiber Reinforced polyester Composite'. J.Mater. Environ Sci 3 (6). pp 1109-1116.
[12] Norul Izani M.A, Paridah M.T.,Anwar U.M.K.,Mohd Nor M.Y.,H'ng P.S. (2013). 'Effects of fiber treatment on morphology, tensile and Thermogravimetric analysis of oil palm empty fruit bunches fibers'. Composites: Part B Vol.45. Pp.1251-1257.