Thermal behaviours of hybrid bio particles impregnated coir-polyester composites

K. Christal*[1], G. Sathyamoorthy[1], S. Nandhakumar[1] and S. Jayabal[2]
[1]Department of Mechanical Engineering, M.Kumarasamy College of Engineering, Karur, Tamil Nadu
[2]Department of Mechanical Engineering, College of Engineering and Technology, Karaikudi, Tamil Nadu
***Corresponding author: E-Mail: florachristal@gmail.com**

ABSTRACT

The present investigation aims to study the thermal characteristics of bio-waste and natural fiber reinforced polymer composites in terms of physical parameters essential for their acceptance as marketable products. This work is focused to study the thermal behaviors of hybrid bio particles impregnated coir-polyester composites manufactured by Compression molding process which can further widen its application in the areas prone to thermal stresses. The thermal behaviors of coir fiber (CF) and rice husk (RH) particles reinforced polyester composites impregnated with bio-particles such as boiled eggshell (BES) and groundnut shell (GNS) are studied by means of Thermo gravimetric Analysis (TGA) and Differential Thermal Analysis (DTA). From the observations, thermal analysis revealed weight loss at various consecutive steps and influences of the temperature effects on the bio particulated coir-polyester composites are discussed.

KEY WORDS: Green husk coir, Polyester, Boiled eggshell, Groundnut shell, Rice husk, TGA, DTA.

1. INTRODUCTION

Recent happenings in the field of fiber-reinforced composite (FRC) materials aim to yield user and environmental friendly components, using man-made residues especially in many engineering applications (John, 2008). In our day to day life the researchers are studying the utility of natural products as a base for eco-friendly composites. In the world market, there is an enormous growth because of the use of bio-degradable natural fiber-reinforced polymer composites (NFRPCs) (Koronis, 2013). A leading consultant reported that, the application of natural fiber composites in global market has shown a favorable growth rate and also expected to grow in the future years. This has encouraged the scientists to develop new materials in polymer matrix composites with enormous advantages of huge availability, low risk in health hazards, and increased resistance to abrasion (Bodros, 2007; Kalirasu, 2015).

In this present investigation, the thermal behavior of the rice husk and boiled eggshell impregnated coir fiber reinforced composites and rice husk and groundnut shell impregnated coir fiber reinforced composites are evaluated and compared for their use in engineering applications. The composites are fabricated with addition of bio-particles such as rice husk & groundnut shell and the rice husk & boiled eggshell particles with green husk coir fiber and polyester resin. The fabricated composites were analyzed using TGA and DTA.

2. EXPERIMENTAL METHODS AND TESTING

The Hybrid Composites (300 x300 x3 mm) with varying weight percentage of bioparticles, fiber and resin(7.5 wt of RH+7.5 wt of GNS+25 wt % of CF+60 wt % of polyester,7.5 wt of RH+7.5 wt of BES+25 wt % of CF+60 wt % of polyester content) is manufactured through compression moulding technique (Bharathiraja, 2016). The green husk coir fiber is taken in a length of 30mm and manually mixed with unsaturated polyester resin with addition of Methyl Ethyl Ketone Peroxide and Cobalt Octoate. The composite plate is maintained for 2.6 MPa at 1 hr for curing of lamina. The fabricated specimen was analyzed with help of TGA and DTA from room temperature to 1000ºC at a heating rate of 30ºC/ min purged in the atmosphere air of 20 ml/min (Charlsley, 1992).

TGA (Thermo gravimetric analysis) is used to measure the weight loss or gain as a function of temperature. The fibre content of composites will be measured by applying the heat to sample which removes the resin and the remaining mass can be found. DTA (Differential thermal analysis) records the temperature difference between a substance and a reference material which is later denoted as a function of time or temperature whereas the two specimens are subjected to identical temperature regimes in an environment heated or cooled at a controlled rate. Thermo gravimetric Analysis/ Differential Thermal Analysis (TGA/DTA) experiments were performed on a Perkin–Elmer 4000 (CECRI-Karaikudi) and the equipment was operated in the environment of Nitrogen.

3. RESULTS AND DISCUSSION

TGA/DTA of Ricehusk and Groundnut Shell Impregnated Coir-Polyester Composites: The thermo gravimetric curve shown in Figure.1 indicates the weight loss of the bio particulated coir-polyester composites at the temperature ranges between 25ºC to 800ºC.

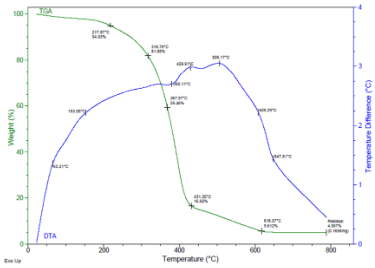

Figure.1. TGA/DTA curve of rice husk and groundnut shell impregnated coir-polyester composites

The bio-particulated coir polyester composites showed weight loss in four consecutive steps. From the TGA graph, it can be inferred that the composite is quite stable till 215ºC as there is only 5% weight loss. This may be because of the little burning of carbonaceous materials which are present in rice husk and groundnut particles. The complete softness of polyester matrix is obtained around 240ºC (softness temp of polyester is 230ºC-240ºC). Beyond 250ºC, there is some significant weight loss and compound starts to undergo a large amount of degradation (melting temp of polyester is 260ºC-270ºC). From 315ºC to 413ºC, there is a drastic decomposition of the sample which leads to nearly 85% weight loss of composite materials. This is mainly due to the degradation of the polyester matrix as well as remaining reinforcements. Degradation of the composite still continues beyond 620ºC with having only 10% of the original composite. So from TGA plot for the composite, it can be decided that the mentioned composite is suitable for low temperature application below 214ºC

The DTA curve shows the peak temperature of 506.17ºC was observed for the bio-particulated coir-polyester composite. There is maximum temperature difference between sample and reference from 300ºC -500ºC.

TGA/DTA of Ricehusk and Boiled Eggshell Impregnated Coir-Polyester Composites: The thermo gravimetric curve shown in Figure.2, indicates the weight loss of the rice husk and boiled eggshell bio particulated coir-polyester composites at the temperature ranges between 25ºC to 800ºC.

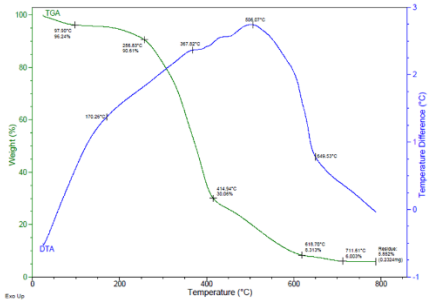

Figure.2. TGA/DTA curve of rice husk and boiled eggshell impregnated coir polyester composites

As in the previous case, here also the bio-particulated coir polyester composites showed weight loss in four consecutive steps. From TGA plot, it can be inferred that the composite is not stable even till 100ºC. At around 98ºC the composite material starts to lose about 4% of its total weight. When the temperature reaches 250ºC, there will be around 10% of weight loss. These are mainly due to the decomposition of the reinforcement materials mainly the coir. Beyond 250ºC, there will be very drastic decomposition of composite material which is mainly due to the degradation of the matrix polyester. When it reaches around 410ºC, material owns only 30% of its initial weight. Later, as the temperature increases material undergoes degradation with less speed. Beyond 600ºC there will be a very less amount of the degradation. This is because of the presence of small amount of $CaCO_3$ in egg shell material which will be stable at lower temperature. When it reaches around 800ºC the residue obtained weighs only 5-6% of the initial composite material. So from TGA plot for the composite, it can be concluded that the composite is suitable for low temperature application below 90ºC.

The DTA curve shows the peak temperature 506.07ºC inferred for the bio-particulated coir polyester composite. There is maximum temperature difference between sample and reference from 360ºC -510ºC.

4. CONCLUSION

This investigation on thermal properties of hybrid bio particulated coir-polyester composites has led to the following specific conclusions:

From TGA curve of rice husk and groundnut shell bio particulated coir-polyester composites it is clear that this composites are best for low-temperature application below 215ºC but certainly not for very high-temperature applications. The DTA curve implies that the sample undergoes main decomposition between 300ºC-500ºC as exothermic peak shows maximum between these temperatures. From TGA curve of rice husk and boiled eggshell bio particulated coir-polyester composites it is clear that this composite is suitable for low temperature application below 100ºC.The DTA curve implies that the sample undergoes main decomposition between 360ºC to 510ºC as exothermic peak shows maximum between these temperatures.

REFERENCES

Athijayamani A, Manickam C, Kumar J, Natesan Diwahar, Mechanical and wear behaviors of untreated and alkali treated roselle fiber-reinforced vinyl ester composite, Journal of Engineering Research, 3 (3), 2015.

Bharathiraja G, Jayabal S, Kalyana Sundaram S, Rajamuneeswaran S, Manjunath BH, Mechanical Behaviors of Rice Husk and Boiled Egg Shell Particles Impregnated Coir-Polyester Composites, In Macromolecular Symposia, 361 (1), 2016, 136-140.

Bodros E, Pillin I, Montrelay N, Baley C, Could biopolymers reinforced by randomly scattered flax fibre be used in structural applications?, Composites Science and Technology, 67 (3), 2007, 462-70.

Chandrasekar M, Rajkumar S, Valavan D, A review on the thermal regulation techniques for non-integrated flat PV modules mounted on building top, Energy and Buildings, 86, 2015, 692–697.

Charsley EL and Warrington SB, Thermal analysis, techniques and applications, Royal Society of Chemistry UK, 117, 1992.

John MJ and Thomas S, Biofibres and biocomposites, Carbohydr Polym, 71, 2008, 343-364.

Kalirasu S, Rajini N, Jappes JW, Uthayakumar M, Rajesh S, Mechanical and machining performance of glass and coconut sheath fibre polyester composites using AWJM, Journal of Reinforced Plastics and Composites, 34 (7), 2015, 564-580.

Karthe M, Tamilarasan M, Prasanna S.C, Manikandan A, Experimental Investigation on Reduction of NOx Emission Using Zeolite Coated Converter in CI Engine, Applied Mechanics and Materials, 854, 2017, 72-77.

Koronis G, Silva A, Fontul M, Green composites, a review of adequate materials for automotive applications, Composites Part B, Engineering, 44 (1), 2013, 120-7.

Krishnan M, Karthikeyan T, Chinnusamy TR, Venkatesh Raja K, A novel hybrid metaheuristic scatter search-simulated annealing algorithm for solving flexible manufacturing system layout Eur J Sci Res, 2012, 52-61.

Manickam C, Kumar J, Athijayamani A, Karthik K, Modeling and multiresponse optimization of the mechanical properties of Roselle fiber-reinforced vinyl ester composite, Polymer-Plastics Technology and Engineering, 54 (16), 2015, 1694-1703.

Prabhu T, Ramesh C, Kumar J, Sivakuma S, Hybrid Solar PVT System based on Neural Network Models to track optimal Thermal and electrical power, International Journal of Applied Engineering Research, 10 (28), 2015, 22075- 22081.

Prasanna S.C, Ramesh C, Manivel R, Manikandan A, Preparation of Al6061-SiC with Neem Leaf Ash in AMMC's by Using Stir Casting Method and Evaluation of Mechanical, Wear Properties and Investigation on Microstructures, Applied Mechanics and Materials, 854, 2017, 115-120.

Prasanna S.C, Ramesh C, Property Evaluation of Aluminum Metal Matrix Composites Fabricated Using Stir Casting Method for Hand Lever In Automobile Applications, International Journal of Applied Engineering Research (IJAER), 10 (85), 2015.

Rajakumar S, Balasubramanian V, Balakrishnan M, Friction surfacing for enhanced surface protection of marine engineering components, erosion-corrosion study, Journal of the Mechanical Behavior of Materials, 25 (3-4), 2016, 111–119

Ramesh C, Manickam C, Prasanna S.C, Lean Six Sigma Approach to Improve Overall Equipment Effectiveness Performance, A Case Study in the Indian Small Manufacturing Firm, Asian Journal of Research in Social Sciences and Humanities, 6 (12), 2016.

Ramesh C, Valliappan M, Prasanna S.C, Fabrication Of Ammcs By Using Stir Casting Method For Hand Lever, International Journal of New Technologies in Science and Engineering, 2 (1), 2015.

Ramesh M Karthikeyan T, Effect of Reinforcement of Natural Residue (Quarry Dust) to Enhance the Properties of Aluminium Metal, Journal of Industrial Pollution Control, 2013.

Ramesh M, Karthic KS, Karthikeyan T, Kumaravel A, Construction materials from industrial wastes—a review of current practices, International journal of environmental research and development, 2014, 317-324.

Ramesh R, Ramesh C, Design, analysis and fabrication of canard wing configuration, International Journal of Research and Innovation in Engineering Technology, 2 (9), 2016.

Sethusundaram P.P, Arulshri K.P, Mylsamy K, Biodiesel blend, fuel properties and its emission characteristics Sterculia oil in diesel engine, International Review of Mechanical Engineering, 7 (5), 2013.

Sivaraman B, Padmavathy S, Jothiprakash P, Keerthivasan T, Multi-Response Optimisation of Cutting Parameters of Wire EDM in Titanium Using Response Surface Methodology, Applied Mechanics and Materials, 854, 2017, 93-100.

Vijayan V, Karthikeyan T, Design and Analysis of Compliant Mechanism for Active Vibration Isolation Using FEA Technique, International Journal of Recent Trends in Engineering, 1 (5), 2009.