Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 3, Issue 11; July-September, 2016, pp. 1022-1024

http://www.krishisanskriti.org/Publication.html

Effect of Filler Content on Thermal Properties of Municipal Solid Waste and Bahunia Racemosa Fiber Composites

J. Ronald Aseer[1], Abhilash Karakoti[2] and K. Sankaranarayanasamy[3]

[1]School of Mechanical Engineering, Galgotias University, Greater Noida, UP, India
[2]Department of Mechanical Engineering, Noida International University, Greater Noida, UP, India
[3]Department of Mechanical Engineering, NIT, Tiruchirappalli, Tamil Nadu, India
E-mail: [1]j.ronaldaseeer@galgotiasuniversity.edu.in, [2]karakoti.abhilash@gmail.com, [3]ksnsamy@nitt.edu

Abstract—*In recent years, the proper utilization of natural fiber reinforced composites are increasing under different environmental conditions. Several natural fibers such as banana, sisal, jute, etc. are used as an effective reinforcement in polymer composites. Fillers in the form of fibers or particles are processed with polymers to attain preferred thermal properties. The analysis of thermophysical properties has been important for various applications such as heat exchangers, electronic products, etc. Thermal conductivity, thermal diffusivity and specific heat are the significant properties required to analyze the heat transfer in composite materials. In this work, the thermal properties of fiber composites were investigated as a function of the total volume fraction of filler (MSW+ Bahunia racemosa fiber). The total volume fraction (V_f) of filler was established by keeping the relative volume fraction of MSW and Bahunia racemosa as 50:50. The transverse thermal conductivity and diffusivity of composite specimens were measured by using a guarded heat flow meter. Thermal conductivity and diffusivity of the composite were decreased with increase in filler content.*

Keywords: *Volume fraction, Thermal conductivity, Bahunia racemosa fiber, Composites, Municipal solid waste*

1. INTRODUCTION

In the last few years, natural fiber reinforced green composites reached a large attention of researchers in the area of aerospace, automotive, and other industries due to their distinctive characteristics of low density, high specific properties, biodegradability, and low-cost compared with synthetic fiber reinforced composites [1,2]. The measurement of thermal conductivity is very much essential in the natural fiber reinforced composites. Natural fibers consist of cellulose decrease the thermal conductivity compared with other conventional fibers such as glass fiber and carbon fiber. Thermal conductivity of composite is similar to the elastic modulus of materials [3]. Some theoretical models were developed to find the thermal conductivity of composites [4-7]. Heat flow meter [8] or the transient plane source method [4] was used to evaluate the thermal conductivity of polymer composites. Specific heat capacity of composites was analyzed by differential scanning calorimeter (DSC) [9]. Agrawal et al. [10] analyzed the effect of fiber surface state on the thermal conductivity of natural fiber composite. Thermo physical and Fire properties of Sansevieria fiber-reinforced polyester composites was analyzed by Ramanaiah et al. [11]. Many researchers studied the thermal behavior of synthetic fiber reinforced polymer composites [12, 13]. The removal of the large amount volume of Municipal solid waste (MSW) would be difficult through the landfills and alternate methods of disposal, etc. Hence, proper utilization of MSW as a value added product has become the need of the hour. In environmental, technical, and cost reasons, there is an increased attention in using MSW as filler in composite manufacturing industries. However, the reported research on thermal properties of MSW as filler in composite is limited. In this study, the effect of the filler volume fraction of MSW and bahunia racemosa fiber on thermo-physical properties of composites was investigated.

2. MATERIALS AND METHODS

2.1 Raw Materials

In this work, MSW and Bauhinia racemosa (BR) fiber were used for fabricating the composite specimen. MSW was collected from residential institution, which mainly consists of vegetable waste, fruit peels, etc. It was dried in sunlight for 24 hours and ground by a pulverizer. The powdered MSW wass screened to remove excess fines by sieve shaker machine over a screen size of 25 meshes (600μm). The BR fiber was collected from Hogenakkal, Krishnagiri District, Tamilnadu, India. Phenol formaldehyde resin (PF) was procured from the SS polymer, Chennai. The properties of PF resin are given in the Table 1[14].

Table 1: Properties of PF resin [14]

Appearance	Brown colour
Viscosity (CPS)	18-22
Water tolerence	1:18
Solid content %	50

2.2 Composite Preparation

Chopped Bauhinia racemosa (BR) fiber of 30 mm length were used to prepare the specimen. The MSW, Bauhinia racemosa (BR) fiber and UF resin are mixed in a blender. Initially, BR fiber is dried in sun light to remove the moisture. The composites are prepared by varying the filler volume ratio of MSW and bahunia racemosa fiber. The blended particles and fiber are transferred to moulding box of size (150x150 mm). The processed composite is pressed hard with a load of 40 tones under hydraulic press and the excess resin is removed and dried for 24 hours. Curing is done at a temperature of 150^0C under constant pressure of 2.5 MPa for 24 hours. The composites were prepared by keeping the relative volume fraction of MSW and bahunia racemosa fiber as 50:50.

2.3 Thermal Properties Measurement

The thermal conductivity and diffusivity of composite materilas were measured by using a guarded heat flow meter, Unitherm model 2022, ANTER Corporation, USA. The circular test samples of 50 mm diameter and 3 mm thickness were cut from the composites for the this study. These properties were determined according to ASTM: E1530-11. Thermal diffusivity was calculated by the following equation 1 [15]

$$a = \frac{k}{\rho C_p} \qquad (1)$$

where

k - thermal conductivity of composite

a - thermal diffusivity of composite

ρ - density of composite

C_p - specific heat capacity

The specific heat capacity (C_p) of composites was found using a differential scanning calorimeter analyzer (NETZSCH, STA 449 F3) at a heating rate of 10^0C/ min. A digital weighing balance was used to measure the weight of the composites used for thermal measurements. Differential thermal analysis (DTA) measurements were carried out using a differential scanning calorimeter analyzer (NETZSCH STA 449 F3) in nitrogen atmosphere (200 ml/min) in a temperature range of 30-500^0C at a heating rate of 10^0C/min.

3. RESULTS AND DISCUSSION

The thermal conductivity values of composite specimen with different volume fractions of filler are given in Table 2. It is clearly shown that thermal conductivity of the composites decreased with filler content increased. This is due to the hollow cellular structure of the fibers which cause a decrease of conductivity [16]. The thermal conductivity of composite at maximum volume fraction of filler was 0.164 W $m^{-1}K^{-1}$ It is 34% lower than that of pure PF resin. As the volume fraction of filler increases, the reduction in thermal conductivity of composite is expected due to lower thermal conductivity of fiber. Similar trend was reported elsewhere [16, 3]. The addition of bahunia racemosa fiber in the PF matrix decreases the heat transfer in the composite. Also, the hydroxyl groups present in the fibers make them less available for conduction. The thermal diffusivity and specific heat behavior also decreases with the increase of the filler loading.

Table 2: Thermal conductivity, thermal diffusivity and specific heat of MSW/bahunia racemosa composites at different filler loading (ratio of MSW: bahunia racemosa fiber =50:50)

Volume ratio of the filler (MSW + bahunia racemosa fiber)	Thermal conductivity, k (W/m K)	Specific heat, C_p (J/kg K)	Thermal diffusivity, a (m^2/s) x 10^{-7}
Neat PF resin	0.25±0.1	1206±0.3	1.96±0.1
20% V_f	0.192±0.2	1010±0.2	1.64±0.4
30% V_f	0.185±0.3	981±0.1	1.61±0.2
40% V_f	0.177±0.1	962±0.2	1.57±0.3
50% V_f	0.164±0.2	941±0.2	1.48±0.4

The effect of temperature on thermal conductivity composite is shown in Fig. 1. It was observed that there is a increasing of thermal conductivity of composite with the increase of temperature.

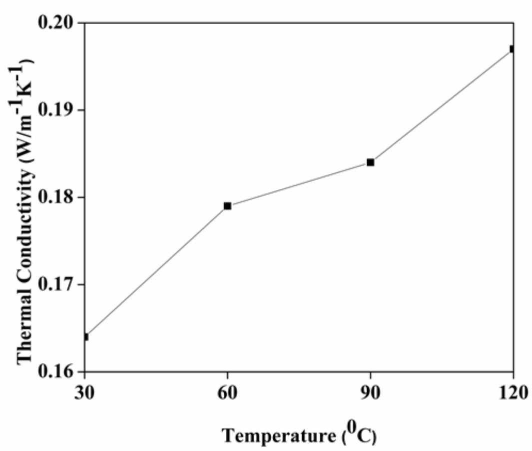

Fig. 1: Thermal conductivity of composite varying with temperature at 50% V_f filler

4. FURTHER SCOPE

A suitable technique has to be developed for the extraction of nanofibrils from bahunia racemosa fiber and nano municipal solid waste. High performance Nano composites can be developed using additon of nanofibrils and nano filler.

5. CONCLUSION

Composites were prepared from MSW/bahunia racemosa composite and phenol foemaldehyde matrix resin. The thermophysical properties of the composites were analyzed based on various filler loadings. The results indicated that thermal conductivity of the composites decreases with increase in volume fraction of filler. The addition of bahunia racemosa fibers into PF resin, resulting decrease of the thermal conductivity of the composites. The developed composites can be used for various applications such as automobile interior parts and building construction due to the best thermal properties.

REFERENCES

[1] Karus, M., Ortmann, S., Gahle, C., and Pendarovski, C., "Naturfasereinsatz nimmt weiterzu", *Composite Material*, 1, 2007, 28–34.

[2] Netravali, A.N., "Advanced ‘green’ composites", *Advanced Composite Materials*, 16(4), 2007, 269–82.

[3] Indicula, M., Boudenne, A., Umadevi, L., Laurent I., Yves,C., and Thomas, S., "Thermophysical properties of natural fiber reinforced polyester composites", *Composite Science and Technology*, 66, 2006, 2719–25.

[4] Kalaprasad, G., Pradeep. P., Mathew, G., Pavithran, C., and Thomas, S., "Thermal conductivity and thermal diffusivity analysis of low density polyethylene composites reinforced with sisal, glass and intimately mixed sisal/glass fibres", *Composite Science and Technology*, 60(16), 2000, 2967–77.

[5] Tavman, I.H., "Effective thermal conductivity of isotropic polymer composites", *International Communication in Heat and Mass Transfer* , 25(5), 1998, 723–32.

[6] Zou, M., Boming, Y., Zhang D., and Ma Y., "Study on optimization of transverse thermal conductivities of unidirectional composites", *Journal of Heat Transfer*, 125, 2003, 981–7.

[7] Zhou ,H., Zhang, S., and Yang, M., "The effect of heat-transfer passages on the effective thermal conductivity of high filler loading composite materials", Composite Science and Technology, 67, 2007, 1035–40.

[8] Kim, S.W., Lee, S.H., Kang, J.S., and Kang, K.H., "Thermal conductivity of thermoplastics reinforced with natural fibers", *International Journal of Thermoplastics* 27, 2006, 1873–81.

[9] Li, X., Tabil, L.G., Oguocha, I.N, and Panigrahi S., "Thermal diffusivity, thermal conductivity, and specific heat of flax fiber-HDPE bio composites at processing temperature", *Composite Science and Technology*, 68, 2008, 1753–8.

[10] Agrawal, R., Saxena, N.S., Sreekala, M.S., and Thomas, S., "Effect of treatment on the thermal conductivity and thermal diffusivity of oil-palm-fiber-reinforced phenolformaldehyde composites", *Journal of Polymer Science Part B: Polymer Physics*, 38(7), 2000, 916–21.

[11] Ramanaiah, K., Prasad, A.V.R., and Reddy K.H.C., "Mechanical, Thermo physical and Fire properties of Sansevieria fiber-reinforced polyester composites", *Materials and Design*, 49, 2013, 986-991.

[12] Laosiriphong, K., "Theoretical and experimental response of FRP bridge deck under thermal loads", Ph.D. Dissertation, West Virginia University, 2004.

[13] Pattanayak, S,, Raju, R.V.S., Kanagaraj, S., "Insulating property of polyurethane-kevlar composites at low temperatures", *International Journal of Plastics Engineering Technology*, 4, 2000, 47–58.

[14] Joseph, S., Sreekala, M.S., Oommen, Z., Koshy, P., and Thomas, S., "A comparison of the mechanical properties of phenol formaldehyde composites reinforced with banana fibres and glass fibres", *Composites Science and Technology*, 62 *2002, 1857–1868.*

[15] Ozisik, M.N. *Heat transfer- A basic approach*. International edition, Singapore, Mc Graw-Hill Book Co, 1985.

[16] Li, X., Tabil, L.G., Oguocha, N., and Panigrahi, S. Thermal diffusivity, thermal conductivity, and specific heat of flax fiber-HDPE bio composites at processing temperature", *Composite Science and Technology*, 68, 2008, 1753-8.