Investigation of Thermal Conductivity of Raphia Fibre (Piassava) from Raphia Hookeri

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Abstract

*This study focused on the investigation of thermal conductivity of Raphia fibre (Piassava) extracted from one of the species of Raphia palm called `Raphia hookeri,` obtained from Ikot-Epkene Local Government Area of Akwa-Ibom State, Nigeria. The Lee's disc apparatus was employed for the investigation. The calculated value of thermal conductivity of the Raphia fibre sample was 0.0876*$WM^{-1}K^{-1}$*. Materials with low thermal conductivity below 0.25*$WM^{-1}K^{-1}$ *are good for thermal insulation. The thermal conductivity of this sample (Raphia fibre) is 0.163*$WM^{-1}K^{-1}$ *below the established value of 0.25*$WM^{-1}K^{-1}$*. This makes this fibre a potential insulating material for some engineering applications such as cooled building designs, kitchen utensils, and insulation of electrical materials. The sample is bio gradable and environmentally friendly.*

***Keywords**: Investigation, Thermal Conductivity, and Raphia Fibre*

Introduction

The terrestrial environment that serves as man's abode is replete with all types of material. These materials are generally categorized into three states of matter- solid, liquid and gas.

Considerable comparisons about the state of matter have been clearly explained by well known scientists, especially in material science applied science which is concerned with the study of correlation between the composition, structure and properties of materials. The type of bond that appears between elementary particles in a material determines the electrical, thermal, chemical and mechanical properties of a given material. According to Helmenstine (2014), physical properties are those characteristics that one can observe and measure. This does not require change in nature or chemical composition of the material. Every material in the universe has their unique physical and chemical properties. Some materials exhibit some sorts of similarity and diverse contrasts.

This work examines one of the physical properties (thermal conductivity) of African piassava (fibre) obtained from one of the species of Raffia Palm called Raphia hookeri. Vitalis et aal (2012) described thermal conductivity as how easily heat can be transported through a material**.**

The essence of determining this property (thermal conductivity) is to establish whether the sample could be utilized in some engineering applications as to augment the low status of engineering inputs in Nigeria, and discourage overdependence on foreign and artificial materials at the expense of abundant, cheap and environmentally friendly local materials.

History of Raffia Palm

Etymology: The generic name of raffia is 'raphis', meaning needlike, describing the pointed structure of its fruits (Guglielmo, et aal, n.d). Raphia palm are about twenty species. They are commonly found in the tropical regions of Africa, Madagascar republic, Amazonia, Philippines (Tagne et aal, 2014; Asuodini & Elijah, 2015). Raphia palms grow to about 52.5ft (16m) (Glen, 2004). Their compound pinnate leaves are the longest in the plant kingdom (Abebooks.uk, 2012; Fair Child Tropical Botanical Garden, 2008).

Uses of Raphia fibre: The Raphia fibres have a number of uses, ranging from weaving of hats, baskets, mats, hammocks and ceremonial costumes (Brink, & Achigan-Dako, 2012; The Columbia Encyclopaedia, 2016). Others are climbing loops and agricultural purposes. Additionally, all other parts of raffia palm are useful to the people of Niger Delta of Nigeria (Oduah and Ohimain, 2015).

Properties of piassava: Raphia fibre is obtained from raphia palm. According to McAdam (2014)., Amasuomo & Amasuomo, (2016),the Raphia fibre is soft, pliable and non-shrinking when it is wet. A study of the diffusion of water based on the phenomenon of absorption by Raphia Vinifera fibre shows that the saturation of this fibre with water takes about 600hrs (25days) (Tagne, et aal, 2014). Piassava readily absorbs oxygen, moisture (strongly hygroscopic). It is inflammable due to its high cellulose content (Transport Information (TIS, 2002). Study shows that piassava are lignin rich fibre, 48.4wt % and initiates thermal degradation at 2225^{o} C. Bonelli, et aal (2005) stated that there is an improvement of mechanical performance of recycled high density polyethylene reinforced with piassava treated with silane as a result of fibre polymer matrix interface adhesion. Sathish et aal (2015) showed that Raphia–glass fibre reinforced polymer (Raphia–glass fibre composite) has higher strength than Abaca glass fibre reinforced polymer.

Materials and Methods

The Raphia fibre was obtained from one of the species of Raphia palm called Raphia hookeri in Ikot-Ekpene Local Government Area of Akwa-Ibom State, Nigeria. This sample was cut into bits and crushed into small size, like the grains of sharp sand.

The Lee's disc apparatus was used in the determination of thermal conductivity of the sample.

The set–up consists of a brass slab, C suspended by String from a heavy stand on rest, a hollow cylinder A, through which the steam from a steam water is passed and the sample which has the same diameter as C as indicated by the portion B is placed between **A** and C. A hole is bored near the bottom of cylinder A and the brass slab C to take two thermometers and the two metal cylinders (cylinder A and are nickel plated to give them same emissive power. A stop-watch and a screw gauge were used for time measurement and the sample thikness respectively. Venier caliper was employed for the determination of brass slab and sample diameters.

For the sample, a paper ring of thickness 0.1m was designed to prevent heat losses during the experiment. The internal diameter of the ring which also equals the diameter of the sample was designed to have same diameter with the cylinder **A** and also with the brass slab **C**. The sample was filled into the wooden ring and was placed between the brass slab C and the hollow cylinder A. The whole set-up was hung in air by three strings attached to the brass slab at vertices of an equidistant triangle with respect to the slab. This is shown in Figure 1.

Other instruments used in this experiment are Bunsen burner, Steam can, rubber pipes, tripod stand and strings.

Steam was passed through the hollow cylinder **A** and the temperature from the two thermometers T_1 and T_2 recorded when steady state has been attained. When temperature was steady, steam passes from hollow cylinder through the specimen to the bras slab by radiation and conduction. The rate of escape of heat is proportional to excess temperature of slab over room temperature. The rate of heat loss from slab was found by removing the specimen and heating the slab until T_2 records a temperature up to 10^oC higher than that recorded at steady state. This slab was then allowed to cool and readings of temperature drop were recorded at half a minute intervals until the temperature falls to 10^oC below steady state temperature. The values obtained were used to plot a temperature –time graph.

This is shown in figure2

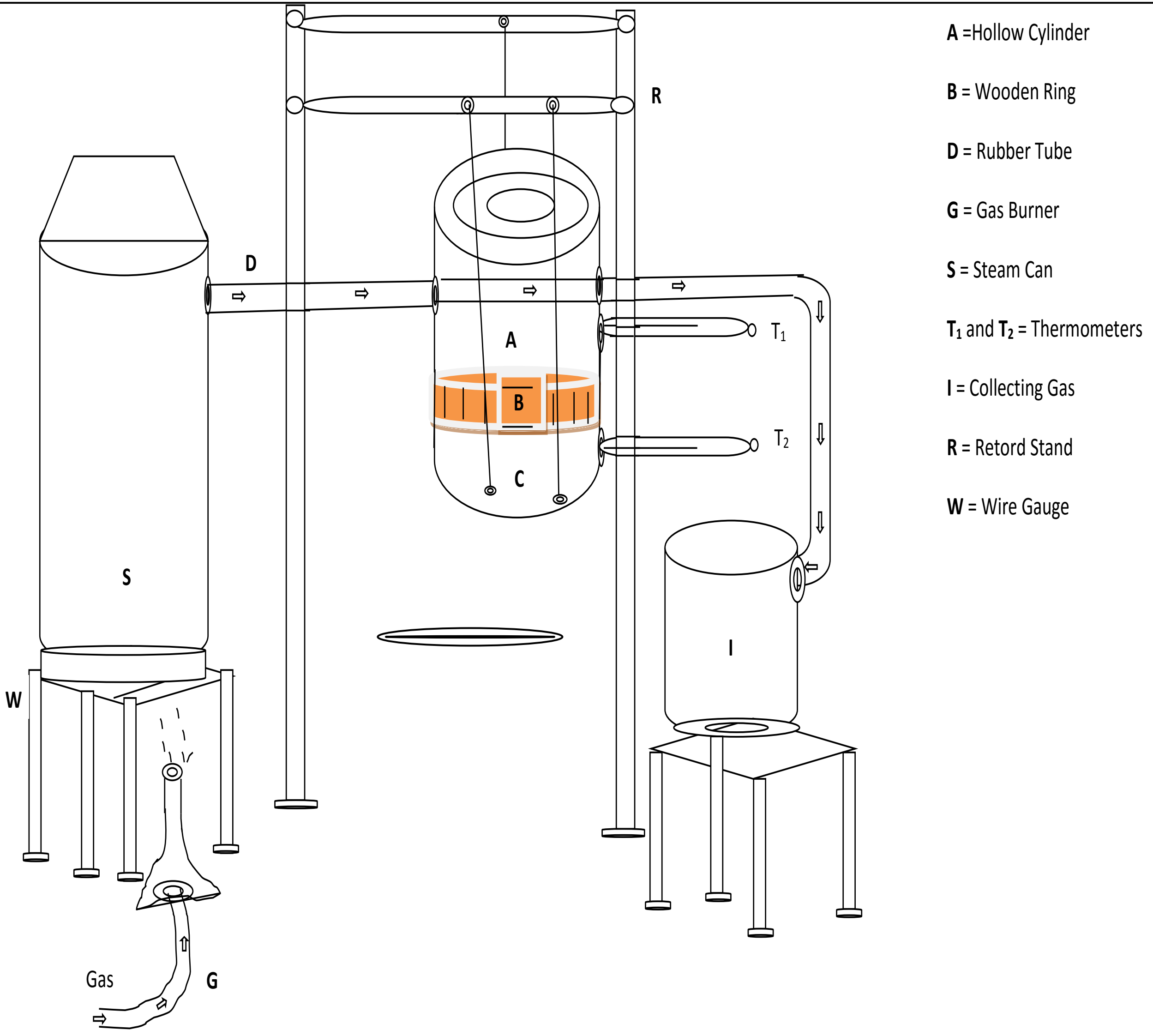

Fig. 1: Lee's Disc Apparatus

Results and Discussion

Results

Table1: Experimental data for the determination of thermal conductivity of raphia fibre

Time (s)	Temperature (^{o}c)
0	56
30	55.5
60	55.0
90	54.5
120	54.5
150	54.0
180	54.0
210	53.0
240	53.0
270	52.5
300	52.0
330	52.0
360	51.5
390	51.0
420	51.0
450	50.5
480	50.0
510	50.0

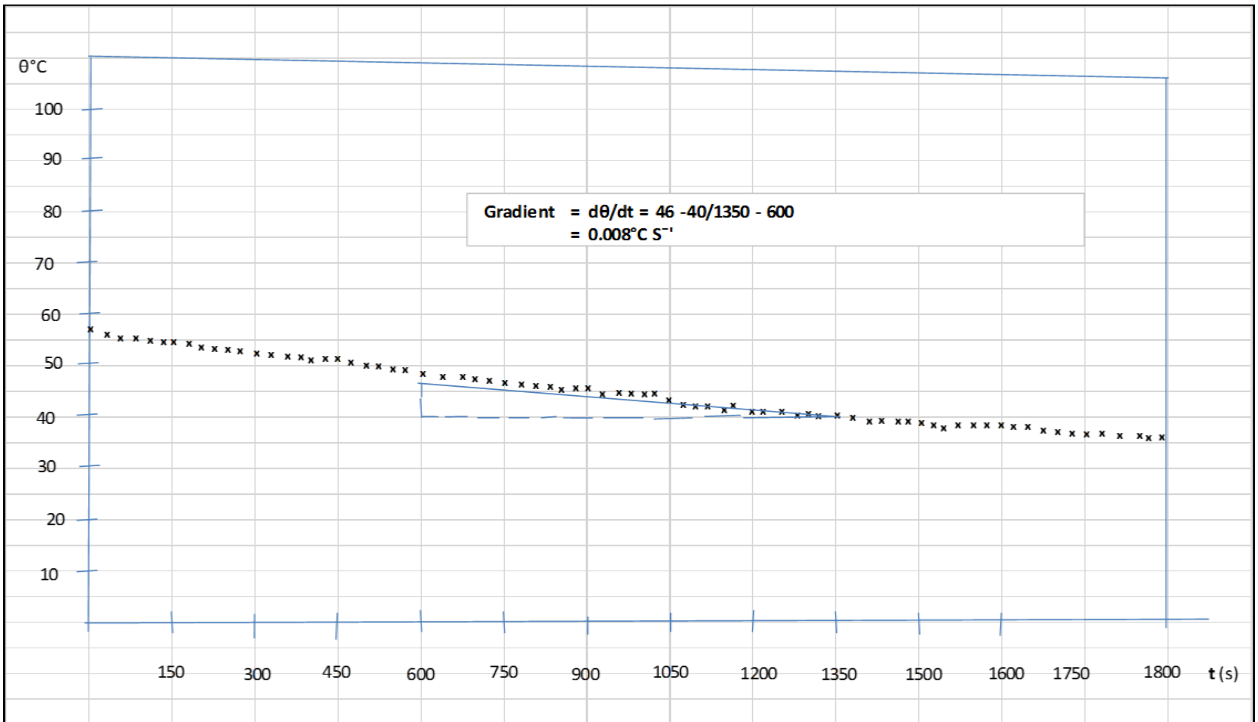

Fig. 2 : Cooling curve for the temperature fluctuation with time

The tangent to the cooling curve gives the rate of heat lost by slab.

Calculation of sample thermal conductivity

Diameter of sample (D) = 0.064m; Radius (r) = 0.032m

Mass of slab (M) = 0.524kg

Thickness of sample (d) = 0.0084m

Specific heat capacity of the brass slab (C_s) = 400$Jkg^{-1}K^{-1}$

Room temperature = 30℃

Temperature of the upper slab (T_1) = 96℃

Temperature of the lower slab (T_2) = 46℃

Steady state temperature of the upper slab = 46℃

Temperature fluctuation with time for the sample as deduced from the graph is given as $\frac{d\theta}{dt}$ = 0.008$°Cs^{-1}$

Thermal conductivity k of the sample is given as;

$$k = Mc\left(\frac{d\theta}{dt}\right)d/A(T_1 - T_2)$$

Where $A = \pi r^2$, i.e. cross sectional area of the sample

$$k = \frac{0.52\ X\ 400\ X\ 0.008\ X\ 0.0084}{3.142(0.032)^2 50}$$

$$k = 0.0876 wm^{-1}k^{-1}$$

Discussion

Table1 and Figure 2 above show experimental data and the cooling curve for the determination of thermal conductivity of the Raphia fibre sample respectively. Paul & Layi (2014**)** stated that thermal conductivity is regarded as the most important characteristic of a thermal insulator since it directly affects the resistance to transmission of heat that a material offers.

Conclusion

The calculated value of thermal conductivity of the Raphia fibre sample was $0.0876Wm^{-1}k^{-1}$. It has been established that materials with low thermal conductivity below $0.25Wm^{-1}k^{-1}$ at temperature between 50^oC and 100^oC are good for thermal insulation (Singal et aal, 2009). From this result, it is clear that the thermal conductivity of Raphia fibre is $0.163Wm^{-1}k^{-1}$ below the established value of $0.25Wm^{-1}k^{-1}$ and therefore, constitutes a good heat insulating material for some engineering applications such as cooled building designs, kitchen utensils, and insulation of electrical materials. Raphia fibre is environmentally friendly as opposed to synthetic fibres. The advantages of natural fibres over synthetic fibres include biodegradability and renewability, low density, low cost, reduced energy consumption, and specific mechanical properties (Obasi, 2013., Everitt et aal ,2013).

References

Abebooks.Co.uk.(2012).Raffia. Retrived Retrieved May 9th, 2016 from www.abebooks.co.uk/9785511137360/Raffia-Palm-5511137367/plp

Amasuomo, T., & Amasuomo, O. J. (2016).Improving Durability of Rural Buildings in Riverine Niger Delta Region: A Case Study on Need to Utilize Appropriate Technology. International Journal of African Society,Cultures and Traditions. 4 (1), 17- 43

Asuodini, A.O., & Elijah, I.O. (2015). Ethnobotany of raffia palm (Raphia hookeri), productivity assessment and characterization of raffia palm oil from the Niger Delta, Nigeria. Research Journal of phytomedicine. 1(1), 33 – 38

Brink, M, and Achigan-Dako, E. G. (Editors) (2012). Plant Resources of Tropical Africa16.Fibres.PROTA-Foundation/CTA.Wagenmgen, Netherland, 2012. pp.39

Bonelli, C.M.C., Elzubair, A., Sunrez,. J. C. M., &Mano, E. B.(2005). Compartamento Termico Mecanico e morfologico de Compositos de Paolietileno de Alta Densidade Reciclado Com Fibrade piacava polimeros: Ciencia e Technologia. 15 (4), 256- 260

Everitt, M. N., Aboulkhair, T. N., & Cliford, J. M. (2013). Looking for Links between Natural Fibres' Structures and Their Physical Properties. Hindawi Publishing Corporation. 2013(2013), Article ID 141204, 10 pages http://dx.doi.org/10.1155/2013/141204

Fair Child Tropical Botanic Garden (2008). Raphia. Retrieved from http://palmguide.org/genus.org/genus.php?

Glen, F. H .(2004).Natal Herbarium. Retrieved May 9th, 2016 from www.plantzafrica.com

Guglielmo, A., Pavone, P., & Salmeri, C. (n.d).The Raphia Palm. Retrieved May 13th, 2016 from www.dipbot.unict.it/palms/Descr04.html

McAdam, C. (Sep 26, 2014). Raffia hats. Butterfly House News, New Collection. Retrieved from http://thebutterflyhouse.net.au/raffia-hats/

Obasi, C. H. (2013). Properties of Raphia Palm Interspersed Fibre Filled High Density Polyethylene. Advances in Material Science and Engineering, vol.2013, Article ID 932143, 5 pages, 2013. doi:10.1155/2013/932143

Paul, P., & Layi, F. (2014). Design of Lee's Disc Electrical Method for Determining Thermal Conductivity of a Poor conductor in the form of a Flat Disc. International Journal of Innovation and Scientific Research. 9 (2), 335-343

Sathish, P., Kesavan, R., & Ramnath, V. (2015). Experimental Investigation on Flexural property of baca and Raffia Hybrid Composites. Asian Research Publishing Network. Journal of Engineering and Applied Sciences.10 (13), 5534 – 5536

Singal, K. R.,Singal, M., Singal, S. (2009). Engineering Thermodynamics. I. K International Publishing House ltd, New Delhi – Bangalore

Tagne, N. R., Njeugna, E., Fogue, M., Drean, J. Y., Nzeukou, A.,& Fokwu, D. (2014). The Scientific World Journal. 2014; 2014

The Columbia Encyclopaedia. (2016). Raffia. Columbia University Press.

Transport Information Service (TIS, 2002). Cargo Loss Prevention Information from German Marine Insurers. Retrieved May 14th, 2016 from http://www.tisgdv.de/tis_e/ware/fasern/piassava/piassava.htm#

Vitalis, C. O.,Olusogo ,O.,& Olawunmi, S.(2012). Laboratory Determination of the Thermal Conductivity of a Typical Nigerian Granite Rock. T*he Pacific Journal of Science and Technology*. 13 (2), 119 - 122