TENSILE PROPERTIES OF RAMIE FIBER REINFORCED EPOXY COMPOSITES

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ABSTRACT
The tensile properties of randomly oriented short fiber lengths from agricultural based plant stems ramie fiber/epoxy composites are described for the first time in this work. Composites were fabricated using raw ramie fibers with varying fiber weight percent's viz. 25, 30, 35, 40 and 45wt. %. The tensile parameter such as maximum stress, Young's modulus and elongation at break were determined using the universal testing machine (UTM). Wet hand lay-up technique was used for the preparation of the composite. Effect of alkali treatment of ramie fiber epoxy composites were also studied on the tensile properties. Ramie fiber epoxy composites showed a regular trend of an increase in properties with fiber weight percent until 40% and afterwards a decrease in properties for composites with greater fiber weight percent. It was observed that the decreased performance was attributed for randomly fabric was due to the fiber agglomerations between the fabric and matrix, there by overlapping between them increased. The analysis of the tensile parameters of short ramie fiber epoxy composites displayed an optimum fiber weight percent at 40wt. %. DSC and TGA of treated and untreated ramie fiber epoxy composites were also studied.

Key words: Tensile Parameter, Ramie Fiber, Composites, DSC and TGA.

1.0 INTRODUCTION
Natural fibers are gaining progressive account as renewable, environmentally acceptable, and biodegradable [2] starting material for industrial applications, technical textiles, composites, pulp and paper, as well as for civil engineering and building activities [6]. The fibers of the plants, such as flax, hemp, linseed, jute, sisal, kenaf, yucca, abaca, or ramie, have outstanding mechanical properties [1] [9]. The first-rate mechanical characteristics of these natural fibers permit the substitution of synthetic, glass, and carbon fibers in a wide range of industrial products [13]. The weight of the natural fibers is about two thirds and the consumption of primary energy for their production is only one third that of glass fibers at a comparable strength [9]. Therefore, natural fibers embedded in plastics will soon compete strongly with conventional reinforcing fibers [10]. Remarkable strength, high stiffness, and dimensional stability of light constructional elements make it possible to essentially reduce the weight of aircraft, trains, trucks, and cars. Technical designers have long been talking about the "end of the metal age," and a silent revolution will take place in the construction of aircraft and vehicles during the next ten years [7]. The industrial application of natural fibers requires making high quality fibers continuously available in large quantities [3] at competitive prices and independently of weather conditions and annual yields. Conventional processing technologies cannot meet the strict demands of modern industries [8]. Consequently, new technologies have to be developed in order to successfully set up powerful process plants for natural bast fiber [11]. Therefore natural fibers can serve as reinforcement not only by improving the strength and stiffness and also reducing weight of the resulting composite materials, although the properties of natural fibers vary with their source and treatment [4]. In order to improve the performance of these composites, the matrix or the reinforcement often needs to be modified. Many aspirants worked on modification of surface of lingo-cellulose fibers and fabric by reinforcing or by short and long fibers or by unidirectional and randomly oriented by coated with coupling agent [5] with different polymers, research with ramie fiber reinforced composites are scanty. In the present research, plant stem of ramie fiber were reinforced into the epoxy resin as a short fiber at different weights viz. 25, 30, 35, 40 and 45wt. %. Randomly oriented fiber orientations were fabricated using short fibers. The tensile parameter such as maximum stress, Young's modulus and elongation at break were determined using

the universal testing machine (UTM). TGA and DSC of treated and untreated ramie fibers epoxy composites were also studied.

2.0 MATERIALS AND METHOD

The epoxy and hardener (Araldite-LY 556 and Amine Hardener- HY 951) employed in this study was supplied by Nycil Company Nigeria Limited. Ramie fiber was extracted from ramie plant stems obtained from the national research institute Umudike's forest, near cross river, Nigeria. Fibers from the stems were extracted by retting method and were kept under the sun over a period of some days. This way 90% of cellulose materials are obtained easily. Then ramie fibers were treated with optimum NaOH solution as depicted in the equation 1:

$$Ramie\ Fiber - OH + NaOH \rightarrow Ramie\ Fiber - O - Na + H_2O \qquad (1)$$

and allowed to soak in the solution for about half an hour. The fibers were washed with water to remove the excess quantity of NaOH sticking to the fibers. Finally the fibers were washed with distilled water and dried in a hot oven at 70ºC for half an hour. For short fibers width and thickness was maintained about 2mm and 0.2 mm was maintained randomly oriented samples, respectively. Then, the fibres were cut into fiber lengths (10mm, 30mm and 50mm). Fibers were cut with sharp scissors and kept in unidirectional orientations in the mould prior to pour into the epoxy modified epoxy mixture. Ramie fibers were placed in the mould in unidirectional manner, and then epoxy/hardener mixer (100:10) ratio was stirred about 30minutes then poured in to the mould. Samples were cast in a mould and cured for 24 hours at room temperature followed by de-moulding processes. Procedure was applied for randomly oriented composite preparation. Tensile tests were conducted using universal testing machine (Instron, Series-3369) with across head speed of 5mm/min. In each case, nine samples were tested and average value tabulated. Authors used 10KN load cell for testing further the sample sizes of 100mm x 20mm x 3mm and supported with span length of 50mm, tensile samples were cut according to ASTM D638. Tests were carried out at room temperature and all the readings were taken by the computer plotter. The thermal characteristics TGA (Thermo gravimetric analysis), DSC (Differential scanning calorimetry) is measured on ramie fibers reinforced epoxy composites using SDT Q600 TGA/DSC (TA Instruments) at a rate of 10°C/min under nitrogen flow. Measurements were carried out at 25°C temperature, 45% relative humidity. The sample undergoes a sinusoidal oscillation at a fixed frequency. At least optimum tests were carried out for each case.

3.0 RESULTS AND DISCUSSION

Tensile properties are shown in the Table1 as a function of fiber loading. Maximum stress, Young's modulus and elongation at break were gradually increases as fiber loading increases from 25wt.% to 40wt.%, but decreases in further increase to 45wt.%. As always treated fiber gets going due to the removal of pectin and lignin, in building interface between fiber matrixes. Tensile strength modulus and elongation at break was improved by 40.4%, 47.8 and 96.6%, respectively for treated/randomly oriented fiber orientation at 40% fiber loading when compared with 25wt. % fiber loading. Creating rough surface by removing all white, grease, lignin, cellulose materials would certainly promotes excellent performance. Fiber agglomerations, in randomly oriented fiber composites, could leave lot of gaps as observed between the fiber and matrix that really makes bulk gaps between them, as a result of that remote chance of hiking performance. In other words, less chances of uniform filling (fiber distribution) in the randomly oriented fiber composites was observed with more chances of overlapping. Another reason is more chances of air entrapment when fiber becomes overlapped, there by crack tip initiation is quiet easy and that makes poor stress transfer.

Table1. Tensile parameters of treated (T) and untreated (UT) ramie fiber's composites as a function of fiber weights

Fiber weight (wt. %)	Max. Stress (N/mm^2) Random UT(T)	Tensile properties Young's modulus (N/mm^2) Random UT(T)	Elongation at break (%) Random UT(T)
25	52.90(53.25)	0.59(0.65)	2.55(2.87)
30	58.80(59.11)	0.62(0.68)	4.28(4.60)
35	64.08(65.06)	0.83(0.97)	4.80(5.29)
40	73.00(75.22)	1.10(1.01)	5.80(6.03)
45	65.01(66.89)	0.90(1.07)	5.74(6.41)

The TGA curves of treated and untreated fibers were shown in the Figure 3.1. The TGA curves of ramie fiber epoxy composites at different time intervals gave two distinct temperature regions were the samples experience significant weight loss. The slight weight loss below 100˚C is due to the moisture present in the untreated fiber. Weight loss was constant for untreated fiber up to 250˚C, and from there on to 450˚C before decomposition occurred for untreated. Treated samples turned out with good weight loss which occurred slightly above the untreated fiber. Weight loss was constant for untreated fiber up to 300˚C and from there on to 500˚C before decomposition occurred for untreated. Generally, fibers become stiffer (modulus) after removal of organic material in the form of lignin and other unwanted materials. This was observed to be the reason in increase in decomposition temperature. This is similar to the observation of [12].

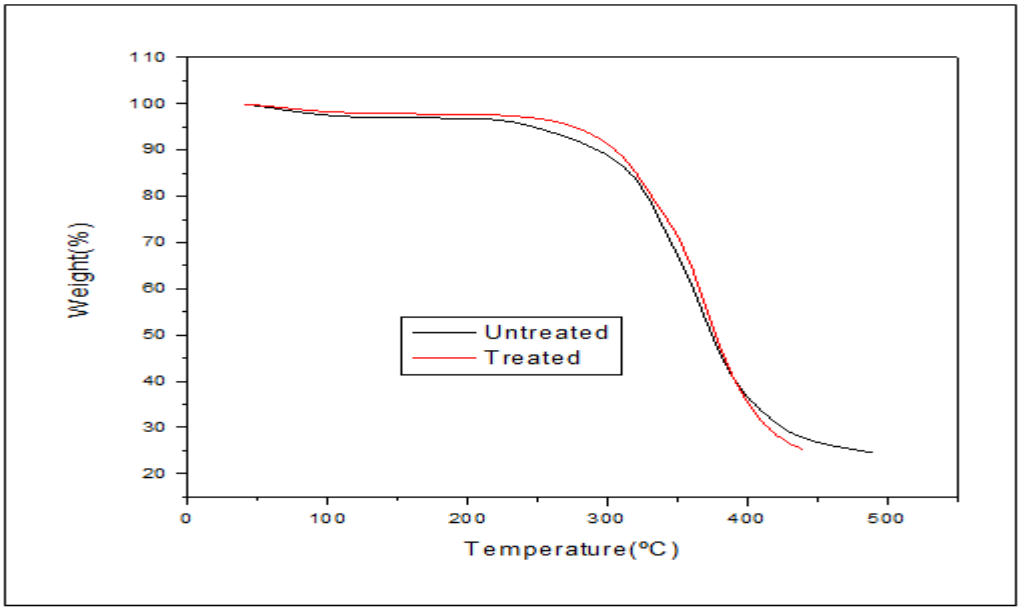

Figure 1: TGA micrograms for ramie fiber before and after alkali treatment with optimum NaOH solution

DSC thermo grams on treated and untreated ramie fiber epoxy composites were shown in the Figure 3.2. The glass transition temperature (Tg) of composite was observed to occur at a temperature of 70°C for untreated; 70.5°C for treated. However, with fiber loading the Tg values do not shift appreciably. From the above figures it was clearly noted that 0.5°C rise in glass transition temperature was observed. Crystallization temperature was observed for untreated to be at 390°C which was improved significantly to about 405°C. An endothermic peak was observed at beyond 500°C for treated and untreated composites.

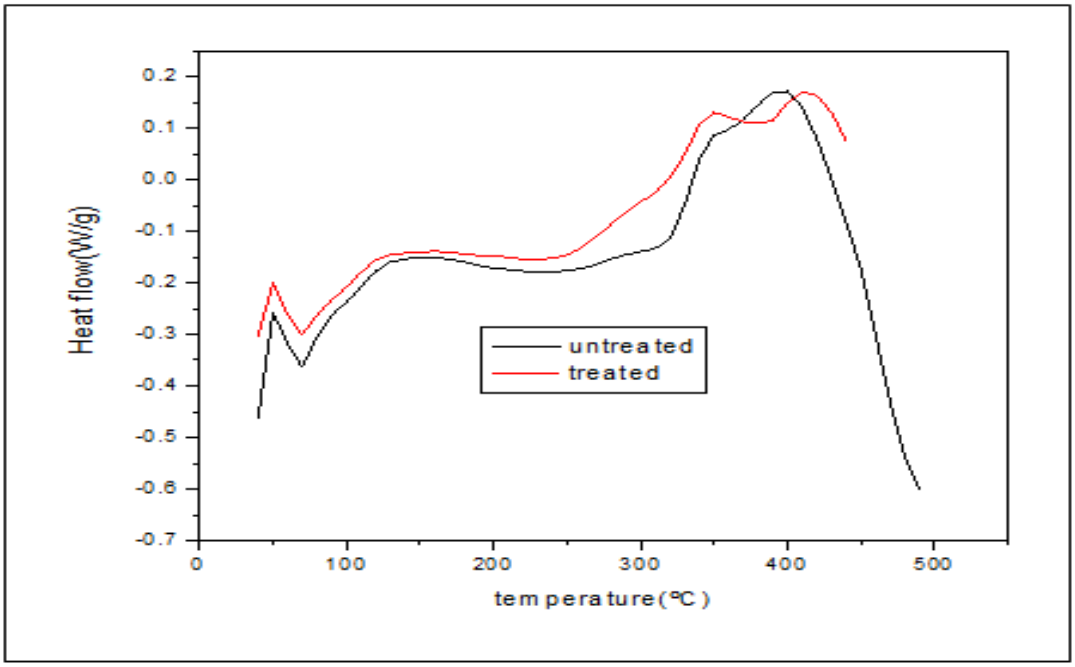

Figure 2: DSC micrograms for ramie fiber before and after alkali treatment with optimum NaOH solution

CONCLUSION

Fiber orientation builds interfacial strength due to more uniform spreading of fiber. Elimination of amorphous hemicellulose by alkali treatment and filling up the rough surfaces with polymer were responsible for this behaviour. It was observed that, performance of treated ramie fibers was optimized at 40wt. % when treated with alkali solution. 50°C rise in decomposition temperature and 4°C rise in glass transition temperature was observed in TGA and DSC measurements.

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