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Extraction, Fabrication and Mechanical Property Characterization of Palm, Fiber Composite Materials

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Abstract

World is as of now concentrating on alternate material sources that are environment agreeable and biodegradable in nature. Because of the expanding natural concerns, bio composite produced out of regular fiber and polymeric resin, is one of the late advancements in the business and constitutes the present extent of experimental work. The use of composite materials field is increasing gradually in engineering. The composite consists of mainly two phases i.e. matrix and fiber. The accessibility of characteristic fiber and simplicity of assembling have enticed scientists worldwide to attempt by regional standards accessible inexpensive fiber and to learning their achievability of fortification determinations and to what degree they fulfill the obliged particulars of great strengthened polymer composite aimed at structural requisition. The advantage of natural fibers is their continuous supply, easy and safe handling, and biodegradable nature. Although natural fibers exhibit admirable physical and mechanical properties, it varies with the plant source, species, geography, and so forth. Palm leaf fiber is one of the abundantly available materials of Ethiopia and has not been studied yet as it is required. A detailed study of mechanical properties will bring out logical and reasonable utilization of palm leaf fiber epoxy composite for various applications. as the experimental work shows the basic mechanical properties of the new composite is comparable with existing synthetic fiber composites, Stress of the new source of material is (356-2097KPa). Tensile modulus of the new source material is (51-414KPa).Strain of the material developed is (5.07-6.97%).Bending strength of the material is 13MPa.hence this is excellent initiation for further study on such leaf areas of natural sources of material.

Keywords- Natural composite, Palm leaf fiber, Tensile strength, Tensile modules, Strain.

I. INTRODUCTION

Material engineering plays a main role in the technological development of human beings and the world in particular. Composite materials are one of the advanced engineering materials that can have unlimited applications, For example, in the aerospace industry, the automotive industry, marine technology, civil engineering, electrical, sports, Chemical sectors, medical sectors for various reasons, such as: medical devices, dressing, life support, diagnostics, etc.

In reality, the use of composite materials compared to monolithic materials has led in significant cost savings, strength, weight, stiffness and life span. This is because monolithic materials alone will not have all mentioned characteristics [1]. In its essence, a composite material is a combination of two or more different materials that are chemically bonded together. Each of the components retains its identity in the composite and retains its distinctive structure and properties. In general, the structure of the composite consists of two phases, the matrix and the reinforcement. The matrix is a continuous phase and the reinforcement is a discontinuous phase. The obligation of reinforcements to achieve the strength of the composite and the matrix has the responsibility of bonding the reinforcements. There is a recognizable interface between matrix and reinforcement materials. Composite materials, however, generally possess a combination of properties such as stiffness, strength, weight, high temperature performance, corrosion resistance, hardness and conductivity that are not possible with the individual components [2].

II. RELEVANT LITERATURES

It is believed that source of petroleum based products are limited and uncertain. So an alternative with cheap sustainable and easily available raw material is required. The countries growing plant and fruit are not for only agricultural purpose but also to generate raw materials for industries.

Most of the developing countries trade lignocelluloses fibers for improving economic condition of poor farmers as much as country support. Recently polymer composites containing cellulosic fibers are under focus in literature as well as industries [3].

According to the paper reported and presented by [4], Composite materials produced by a combination of natural fiber have good mechanical properties, which make the majority of researchers pay attention to natural composites for different applications. In this paper, mechanical properties (tensile, flexural, compression and hardness) are tested for sisal / coir; sisal / hemp and sisal / flax fiber reinforced epoxy hybrid composites are tested according to the ASTM standard.

The study reported and presented by [5] increased demand for new food packaging materials that meet human requirements has given impetus to the advancement of nonmaterial science. Inherent permeability of polymeric materials to gasses and vapors; and poor barrier and mechanical properties of biopolymers have increased interest in developing new strategies to improve these properties. Research and development in polymeric materials coupled with appropriate filler, matrix filler interactions and new formulation strategies to develop composites have potential applications in food packaging.

[6] , The study showed that natural fibers (sisal, kenaf, hemp, jute and coir) reinforced polypropylene composites were processed by compression molding using a film stacking method. The mechanical properties of the different natural fiber composites have been tested and compared. A further comparison was made with the corresponding properties of glass reinforced polypropylene composites in open literature. In most cases, the specific properties of natural fiber composites have been favorably compared with glass.

[7] , Their study, essentially for the purpose of this study, is to introduce the theory of percolation in this field and to carry out some preliminary work. In the first place, two new concepts, accessible fiber ratio and diffusion-permeability coefficient, were defined; in the second place, a percolation model was developed to estimate the critically accessible Fiber ratio; finally, the moisture absorption and electrical conductivity of composites with different fiber loads were investigated.

To summarize the above relevant literature different researchers have done a great job on composite materials as a general and excellent work is still being done on natural composites, due to the abundance of species of plant researchers addressed only some of them, therefore this research will fill gaps in knowledge and research gaps by studying such a new source of materials for light mechanical applications.

III. METHOD OF ANALYSIS

This topic of the research deals with the different types of materials used in the preparation of composites. The chemical treatment needed to make the fiber more suitable for composite manufacturing is also discussed. It also includes the different types of testing equipment needed to characterize the specimen.

1. **Extraction of Fiber**

Figure 1: Fiber extraction process of palm leaf.

Figure 2: Chopped fiber has been produced To perform this treatment effectively the recommended step are following:-

2.Wash the chopped palm with in distilled water at for 1hrs and dry it in sunlight for a days.

3.The second step is palm fiber mercerization. It is a process of treating palm fiber after oven with 10wt% Na OH solution at room temperature for 24hrs.

4. Next rinse the fiber (palm fiber) with water to remove the soda excess until PH ~ 7 will reach.

Finally, the fiber has been dried by sun light.

5. Preparation of epoxy and hardene

OCPOL-711N epoxy resin, mixed with SYSTEM #2060 hardener, is used for the preparation of a composite plate. The ratio of weight to mixing epoxy and hardener is 10:1. The hardeners include anhydrides, amines, polyamides, dicyandiamide, etc. Mixing is done in the mixing containers (bowl) the bowl is made of nickel to prevent the melting of the bowl during the exothermic reaction with the tongue depressor the mixture is done slowly so as not to induce any excess air bubbles in the resin.

6. Hand Lay-Up

Hand-lay-up method was used to fill the prepared mold with an appropriate amount of epoxy resin mixture and layers of random (chopped) palm fibers, starting and ending with resin layers. The quantity of accelerator and catalyst added to the resin at room temperature was 1% by volume of resin each. Fiber deformation and movement should be minimized to produce high quality, random fiber composites.

As a result, at the time of curing a compression pressure of 50 bar (5MPa) was applied to the mold and the air gaps formed by the fibers were gently pressed out by the hydraulic press to force the air between the fibers and the resin, and kept for several hours to obtain the perfect samples, the processed wet composite was then pressed hard and the excess resin was removed and dried.

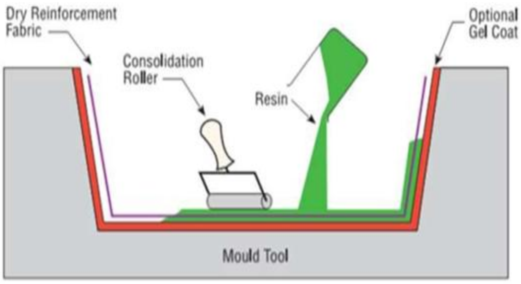

Figure 3: Hand layup [8].

7. Mold Release

The release of the mold is essential to prevent the epoxy from sticking to the mold when the composite is separate. Although several types of mold releases are used depending on the mold material and the desired characteristics of the finished part, the most common type used for this work is paste wax (oil) and polyethylene plastic for better surface finishing of the composite. The composite is dried within 2-3 hours in which the fibers of the palm and the polymers adhere tightly in the presence of a hardener.

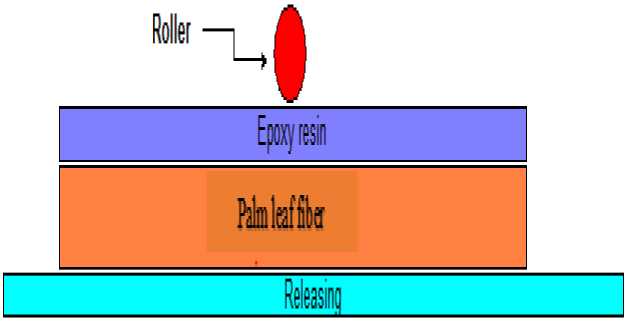

Figure 4: Palm fiber reinforced epoxy composite molding sketch map.

Figure 5: Palm fiber- epoxy resin mixture in the mold surface at Africa Bamboo Lab, Addis Ababa, Ethiopia. Prepared samples from palm leafs 15/85 composition of sample (15% fiber to 85% epoxy).

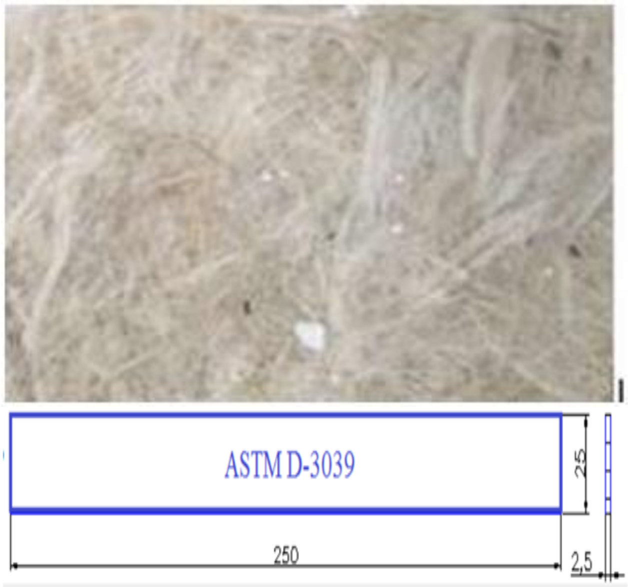

Figure 6: ASTM D-3039 Standard for test sample prepared. [9].

Figure 7: Test specimens were prepared using the band saw in Africa Bamboo Lab, Addis Ababa, Ethiopia.

8. Experimental Test Setups

The tensile test is done as per universal machine which was shown in Fig 8&9, the maximum machine loading capacity was 50KN but for each sample it will not exceeds such limit and all acting loads are below such limits as shown in experiments, the specimen size was 250mm, 25mm width, 5mm thickness, and test result shows very good agreement with relevant literature.

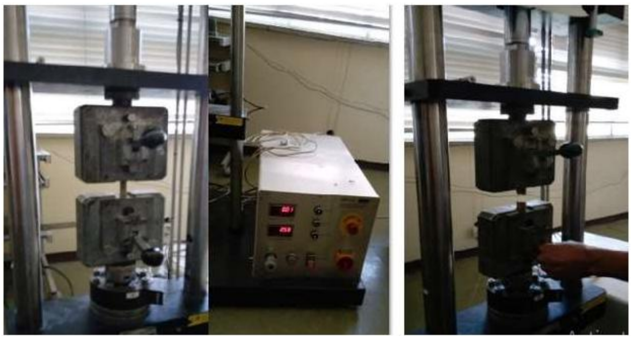

Figure 8: Experimental set up for tension test in Defense University, Bishoftu Ethiopia.

Compression test is done to characterize the compression strength of the Palm leaf fiber epoxy composite for three test samples prepared as per ASTM standard.

Figure 9: Universal Compression Testing Machine at Defense University, Bishoftu Ethiopia.

Figure 10: Experimental setup for bending test in Defense University, Bishoftu Ethiopia.

IV. RESULT AND DISCUSSION

Mechanical properties of composites such as, tensile and compression strength, maximum strain has been investigated and also discussed. The mechanical properties of the composite are mainly depending on many factors such as fiber content and length.

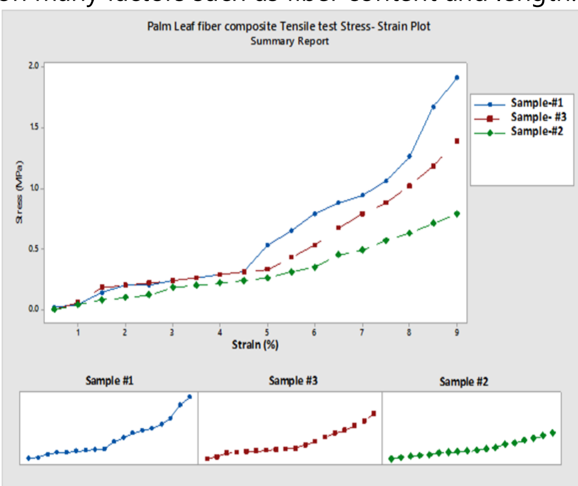

Figure 11: Stress -strain curve of palm leaf fiber epoxy composite:

Figure 11 Sample #1, shows that tension test result of palm leaf fiber epoxy composite stress versus strain curve of Test sample #1, the curve clearly shows as stress increases the corresponding strain increases until the ultimate stress limit (2.14MPa) of the specimen, which means brittle nature of the material is shown.

Figure 11 Sample #2, Shows that tension test result of palm leaf fiber epoxy composite stress versus strain curve of the Test sample #2, the curve clearly shows as stress increases the corresponding strain increases until the ultimate stress (2.14MPa) of the specimen then failure will happen beyond this limit.

Figure 11 Sample #3, Shows that tension test result of palm leaf fiber epoxy composite stress versus strain curve of test sample #3,the curve shows as stress and strain is directly proportional until the ultimate stress limit is obtained (1.1MPa)of the specimen then the specimen will failed to withstand the stress acting on the specimen.

To summarize and tensile report on stress versus strain on palm leaf fiber epoxy composite ash shown in table below

Table -1: Tensile test result for stress –strain curve and tensile module

Sample no.	Standard	Strain (%)	Tensile Stress (N/mm^2)	Young's modulus (N/mm^2)
ST-1	ASTM 3039	4.25	2.14	0.503
ST-2		6.59	2.14	0.325
ST-3		4.36	1.91	0.438
	Mean	5.07	2.097	0.414
	(SD)	1.03	0.0975	0.2011

The mean (Equation 1) and Standard Deviation (SD) of the estimated material properties are tabulated in Table 1. SD (Equation 2) shows how much variation or dispersion from the average exists. A low standard deviation indicates that the data points tend to be very close to the mean (also called expected value), a high standard deviation indicates that the data points are spread out over a large range of values.

Experiments were carried out on three specimens each prepared as per ASTM standards and their tensile strength, Young's modulus, Tensile strength, Strain were calculated. Tensile strength for ASTM D-

3039 [9], possesses a standard deviation of 0.0975, which mean that the observed tensile strength values disperse from the mean value at a smaller range. In case of Young's modulus for D3039 the standard deviation value is very small (0.2011), which indicates that the data points tend to be very close to the mean Young's modulus values.

$$\text{Mean } (\mu) = \frac{\text{Sum of all values}}{\text{Total no of values}} \quad \text{Eq. 1 [10]}$$

$$\text{Standard deviation } (\sigma) = \sqrt{\Sigma(x-\mu)^2} \quad \text{Eq. 2 [10]}$$

Whereas: - x=each values in the sample test, μ=mean value, N= Number of values

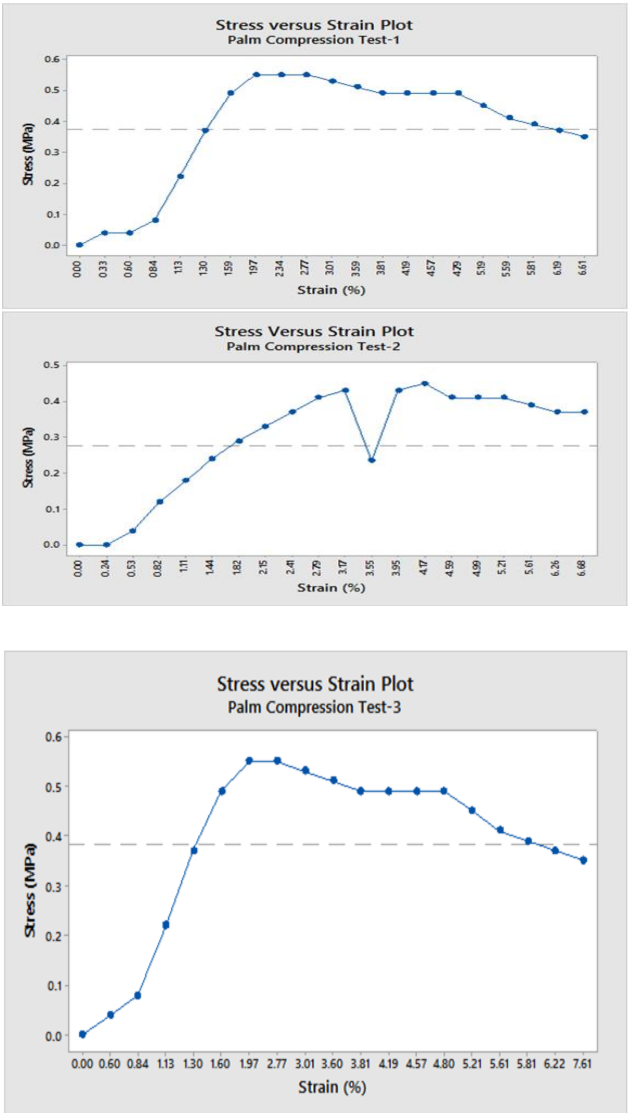

Figure 12: A, B, C, Stress-strain curve for sample #1, 2, 3 respectively.

Table -2: Palm Leaf fiber compression test result for stress –strain curve and tensile module

0	Standard	Strain (%)	Compression Stress (N/mm^2)	Elastic Modulus (N/mm^2)
ST-1	ASTM 3039	6.61	0.35	0.053
ST-2		6.68	0.37	0.055
ST-3		7.61	0.35	0.046
	Mean	6.97	0.356	0.051
	(SD)	0.46	0.003	0.0004

Table -3: Summary of Palm Leaf fiber bending test result of samples.

Specimen Number	Standard	Bending Stress (N/mm^2)	Max Load (N)
ST-1	ASTM 3039	21	70
ST-2		6	20
ST-3		21	70
Mean		13	53.3
Standard Devation		6.164	23.57

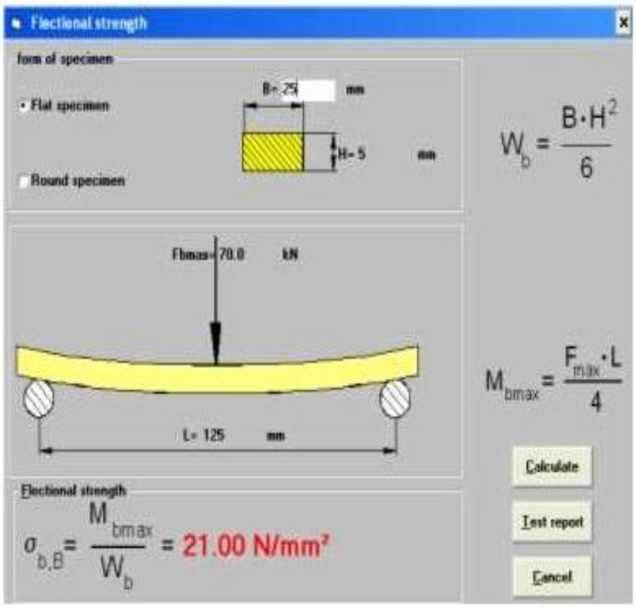

Figure 13: Bending strength of sample #1, same for other two test samples.

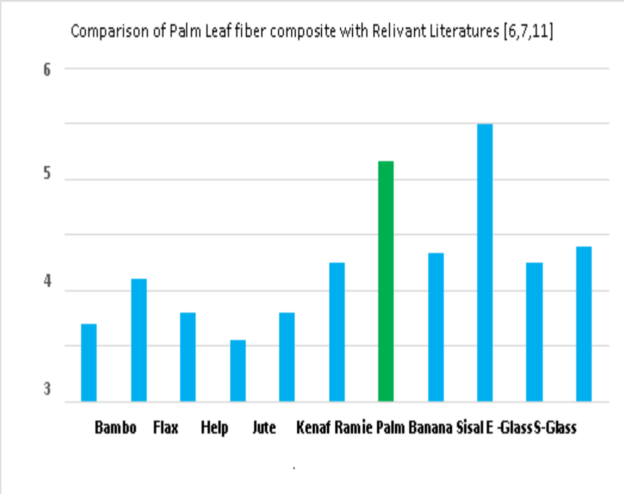

Figure 14: Comparison of palm leaf fiber epoxy composite with existing literatures. [6], [7] [11].

V. CONCLUSIONS

This experimental investigation to characterize the mechanical behavior of palm leaf fiber epoxy composites indicates the fiber have comparable strengths to substitute the glass fiber epoxy composites which have strong environmental influence and cost. Hence this finding can show as how to focus in new source of fiber and making better environmental for 2050.there for the points are the pillar finding of the research work:-

1. Palm leaf fiber epoxy composite have better strength as compared to other plant leaf fiber epoxy composite and both new source of leaf fiber composites have comparable strength with E Glass and other fiber source.
2. Stress of the new source of material is (356-2097KPa).
3. Tensile modulus of the new source material is (51-414KPa).
4. Strain of the material developed is (5.07-6.97%).
5. Bending strength of the material is 13MPa.

VI. RECOMMENDATIONS

This research have been addressed the basic mechanical properties of palm leaf fiber epoxy composite for light mechanical applications and limited to characterize all the recommended works below therefor further researches need to be done on the following areas to strengthen once started novelty work.

1. Characterization of the fibers as a form of mat type and fine powder type.
2. Investigate the contribution of fiber direction, orientation and volume ratio for the benefit of higher mechanical properties.
3. Characterization of fibers can also be done using different fabrication techniques.
4. The physical, chemical, crystalline, and thermal stability analyses were not discussed
5. Finding of different palm and pineapple leaf fiber extraction and treatment processes for the better palm leaf fiber surface texture.
6. Testing like fatigue test, shear test, impact test, moisture content test and thermal test.

VII. ACKNOWLEDGEMENTS

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REFERENCES

[1]. Z. Ru-Min Wang, "Composite Materials.," no. p 3-6., 2018.

[2]. D. Askland, "Composites, In: The Science," Pradeep, pp. (fourth edition). ISBN 0-534-95373-5,, 2003.

[3]. J. Nadlene Razali, "A Study on Chemical Composition, Physical, Tensile, Morphological, and Thermal Properties of Roselle Fibre," bioresources.com, vol. 10, no. 1, pp. 1803-1824., 2015.

[4]. S. Karthikeyan, "Development Of Tailor Made Ptfe Coated Basalt And Jute Composite On Tribological Applications," Kalasalingam University, 2017.

[5]. K. Majeed, "Potential materials for food packaging from nanoclay/natural fibres filled,," Elsevier,, pp. vol. 46,p. 391–410, 2013..

[6]. V. P. Wambua, "Natural fibres: can they replace glass in fibre reinforced plastics," Elsevier, pp. vol. 63, p. 1259– 1264,, 2003.

[7]. W. Wang, "Study of moisture absorption in natural fiber plastic composites," Elsevier, pp. vol. 66, p. 379–386, 2005.

[8]. K. Alawar, "Characterization of treated date palm tree," google scholar, pp. no. part B 40, 601-606, 2009.
[9]. https://www.researchgate.net/, "Hualong-Universal-testing-machine-testing-system," 2019.
[10]. Z. Ru-Min Wang, "Composite Materials," google scholar, pp. no. p 3-6., 2018.
[11]. D. Ibrahim, "Mechanical properties of sisal fibre-reinforced polymer," Composite Interfaces,, pp. VOL. 23,, no. NO . 1, pp. 15-36,, 2016.
[12]. W. Wang, "Study of moisture absorption in natural fiber plastic composites," Elsevier,, pp. vol. 66, p. 379–386,, 2005.