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EFFECT OF FIBRE LENGTHS ON THE MECHANICAL PROPERTIES OF TREATED AND UNTREATED (OPEFB) FIBRE

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Abstract: Fibre lengths has been noticed to have effect on the tensile strength of natural fibres (OPEFB). These observations were made among researchers in different part of the globe. In this paper**,** OPEFB fibre with two different lengths of 100mm and 150mm were considered both untreated and treated with two different concentrations of NaOH (10%w/v and 15%w/v) solution which was allowed for a period of 24hrs in a NaOH solution.It was found that the fibre with 15cm length gave the highest tensile strength when untreated and after treated for 24hrs in the 15%w/v of NaOH solution with the surface morphology been rougher at the same concentration. Therefore, the higher the length of OPEFB fibre, the higher the tensile strength especially when the OPEFB fibre is treated optimally with NaOH solution.Generally, increasing the length of (OPEFB) fibers leads to an increase in tensile strength, but only up to a certain point. Beyond that optimal length or optimal treatment when treatment is required, further increases in length can result in a decrease in tensile strength. This is due to a combination of factors including fiber dispersion, interfacial bonding, and porosity within the fiber.

Keywords: Oil Palm Empty Fruit Bunch (OPEFB), Fibre Length, Tensile Strength, Alkali Treatment, Natural Fibre Composites

Introduction

Agriculture has remained the main stay economy of many countries in including Nigeria for decades of years now. And most of these agricultural products are renewable as well as sustainable.

Therefore, the recent world development is gradually shifting towards the use of eco- friendly materials as a substitute to other materials which are considered to be costly, toxic,and unavailableand at the same time non-biodegradable. This idea came-up because the recent researchers have seen agriculture as the only key towards the national development and sustainability as reported by Ayu et al., (2020).Therefore, the current researchers are seriously concerned about the conversion of waste into wealth through the recycling of agricultural-waste materials simply referred to as green technology in recent time in the building industries according to Kochova, Schollbach,and Brouwers, (2015). Currently, researchers have reported so many factors that influence the mechanical properties of OPEFB fibres such as fibre diameter, the nature of chemical treatment, method of fibre

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extraction etc. Akasahet al., (2019) have reported also that fibre lengths increase the mechanical strength of OPEFB fibre.Meanwhile, shortfibreshave been found to be associated with large surface area when linked with a large hydrogen bond as reported by Bressian et al (2021). However,the tensile strength is measured at higher strains than the elastic modulus; therefore higher fibre lengths indicates more pronounced effects since longer fibres can sustain higher loads when they are strained higher. All natural fibers except silk are of staple length. Whereas textile fibers are either staple or filament. Staple fibres ranges from 2mm to 46mm; filament. Silk and manufactured fibers may be staple or filament fibers. However, Jeyapragash, Srinivasan, and Sathiyamurthy, (2020)have reported that the composite of a natural (OPEFB) fibrehave the ability to carry and sustain load with an increase in tensile strength.Sugiman, Setyawan,andAnshari, (2019) reported also that higher fibre lengths make work easier when combined with a matrix. Soh et al (2018) have reported that the presence of lignin, hemicelluloses and others are the chief cause of poor compatibility among OPEFBfibrecomposites.

Omoniyi, (2019) reported that natural fibres have been in existence for decades of years now since it serves as a perfect substitute to synthetic materials which are costly and non-biodegradable. Besides, naturalfibers associated with many advantages such as non-toxic, high tensile strength, minimal weight and of course with wider applications in geotechnical and civil engineering works above all.
This particularfibre (OPEFB), is cheaply available in west Africa and some of part of Asian countries as found by Mohammad et al.,(2020). Though the existence was first traced to be in Africa but today it has gotten to different part of the world because of its utilizations and wider applications in human endeavors as reported by Ibrahim, (2016), (Danso, (2017), and Abdullah et al., (2019). The eco-friendliness of OPEFB fibre and other numerous advantages speaks volume of it when compared with other natural fibres as reported by Tan et al., (2017), Hassan and Sapuan, (2018). However, the mechanical properties of the OPEFB fibre depends on the fibre diameters hence OPEFB plant is faced with the production of different fibres from different parts of the palmtree with variable diameters. The attention on natural fibres especially the OPEFB fibre is converted from waste to wealth rather than leaving it to become a challenge to the environment as reported by (Dede , Ismail and Fauzi (2022),Mondylaksita et al., (2022).Therefore, it is very obvious that the chemical treatment positively influences both the physical and surface morphology of OPEFB fibre as reported by Godara,(2019) andRamlee,(2019).Whereas the cellulose content enhances the good strength and stiffness of OPEFB fibre and creates a room for compatibility of the fibre and the matrix. Therefore, the mechanical properties of OPEFB fibre depend so much on the cellulose.It isalso important to state that the level of fibre compression in the composites is solemnly depends on the fibre length as a result of the changes in pressure under-going by the fibre per unit area.

Materials and Methods

The material (OPEFB) fiber for this research was locally provided by Uwaoma oil mill industry from ChokonezeMbaise in Imo State. The manually extracted fibrewere obtained after retting process (soaking of OPEFB in water) for a week. The individual fibres were obtained as seen in Fig.1. However, the remaining

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drops of oil impurities were removed by subjecting the OPEFB fibre to further washing using distilled water. After which, it was allowed to dry in air for 24hrs before it was put in a container to avoid further exposure to direct sunlight with clear labeling prior to chemical treatment. The required lengths of 10 and 15cm were cut from the OPEFB bundles and then arranged for testing. The untreated lengths of 10 and 15cm were subjected to a tensile machine and their breaking forces were analyzed as shown in the figures below. Then the chopped 10mm and 15cm of OPEFB fibre was introduced into the following concentrations of alkaline solutions, 10%and 15 %(w/v). In order to achieve a uniform mercerization, the mix was stirred for 30mins.

The mercerized fibres were air-dried for 24hrs in a room temperature. The fibre strands/bundles tensile tests were performed using Monsanto Transometer Testing machine with crushed-head speed of 0.0025cm/min to 100cm/min at room temperature of 25°C (Made in England S/N 8889). The treated and untreated samples were cut into 10mm and 15mm and their bundle diameters were measured using digital venier caliper of 0.001mm precision. Five (5) replications were conducted for each fibre length and conditions. The gripping technique was in accordance to ASTM - D1445 standard.

Fig.(1) Exracted - Untreated) dried OPEFBfibre

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Results and Discussion

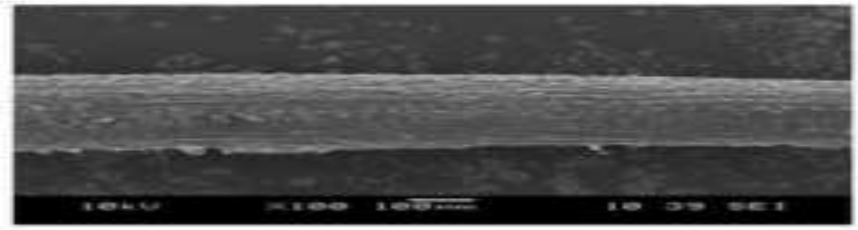

Fig.(2i) Surface Morhology of the treated fibre at 10%

Fig.(2ii) Surface Morphology of the treated fibre at 15%

In Fig (2i), the result of surface morphology at 10%w/v of the fibre treatment after 24hrs shows that lignis,wax and oil contents of the fibre was not completely removed at the given concentration of NaOH solution and therefore appears slightly rougher. Whereas in Fig (2ii), the surface morphologies appear to be rougher at 15% after 24hrs treatment. It is therefore very clear that treatment of fibre done at 15% after 24hrs yield the best result in terms of tensile strength and at the same time yield strong interfacial bond between the fibre and the matrix provided the fibres rough surface is still within the range of tolerable limit as reported by Ridzuan et al (2015),Mbeche and Omara,(2020), Raia, and Iwakiri, (2021)

Result of untreated and treated OPEFB fibre @10cm length

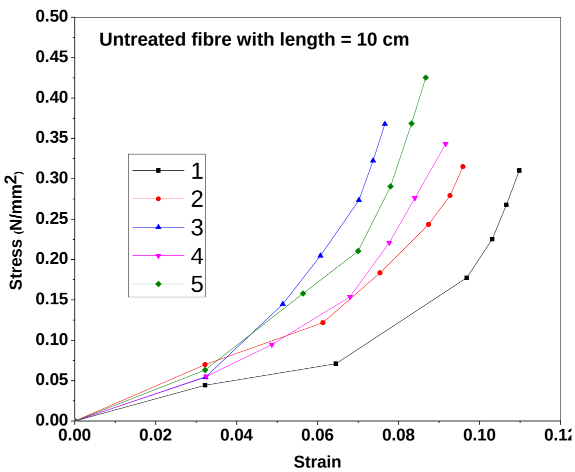

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Fig.(3a) Result of untreatedfibre @10 cm length

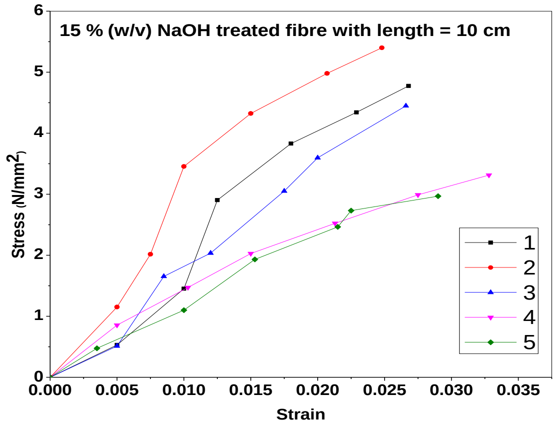

Fig.(3b) Result of 10% treated fibre @10 cm length

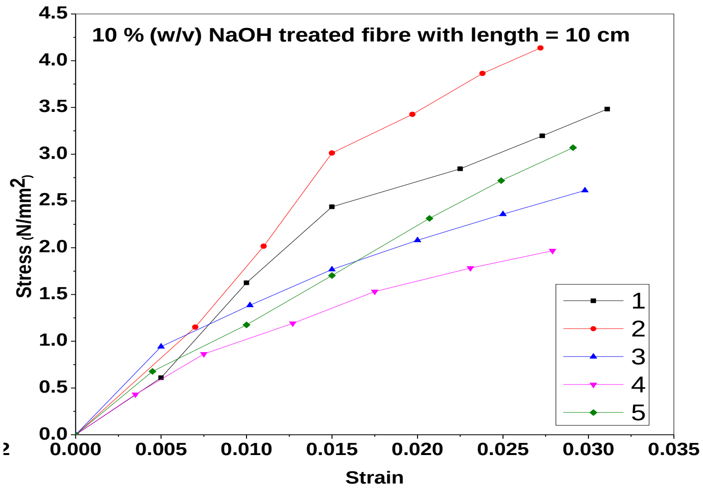

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Fig.(3c) Result of treated 15%fibre @10 cm length

For the untreated fibre with length 100 mm, number 4 has the highest tensile strength of 3.4207 N/mm^2 at a strain of 0.0159, while number 2 shows the lowest tensile strength of 1.7704 N/mm^2 at a strain of 0.0149. When the fibre was treated with 10 % (w/v) NaOH, number 2 exhibited highest tensile strength in the magnitude of 4.1357 N/mm^2 at a strain of 0.0272.Further, when the fibre was treated with a higher concentration of alkali solution (15 %), the tensile strengths increased correspondingly. The tensile strength value of number 2 increased to 5.400 N/mm^2 at a strain of 0.0248. Therefore the modulus of elasticity in the number 4 plot is 215MPa while the corresponding modulus of elasticity for number 2 shows 119MPa. In the same vein, the modulus of elasticity for the treated at 10%w/v, the modulus of elasticity was 152MPa whereas the higher concentration of 15%w/v the modulus of elasticity were recorded as 217MPa. Therefore, the result of tensile strength from figure (3b) to figure (3c) shows that thefibrelength has a greater influence on the mechanical properties of the naturalfibrewhich is in agreement with the research carried out bySarukasan et al., (2021).

Result of treated and untreated fibre Length @ 15 cm

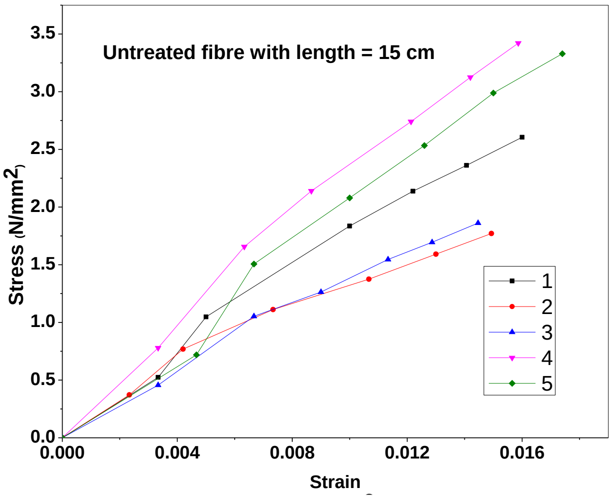

Fig.(4a) Result of untreated OPEFB fibre @ 15 cm length

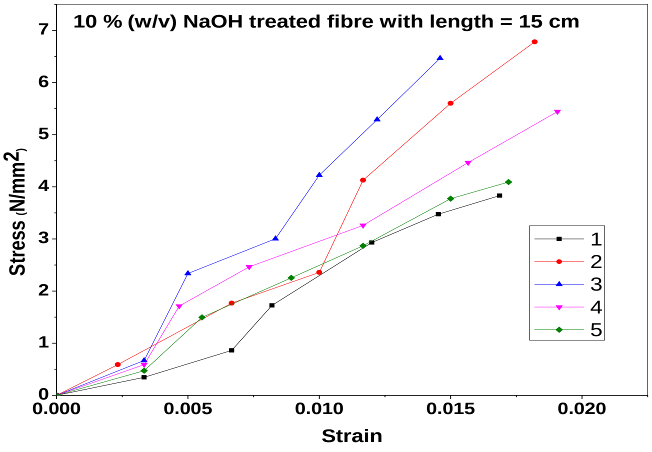

Fig.(4b) Result of 10%w/v treated OPEFB fibre @ 15 cm length

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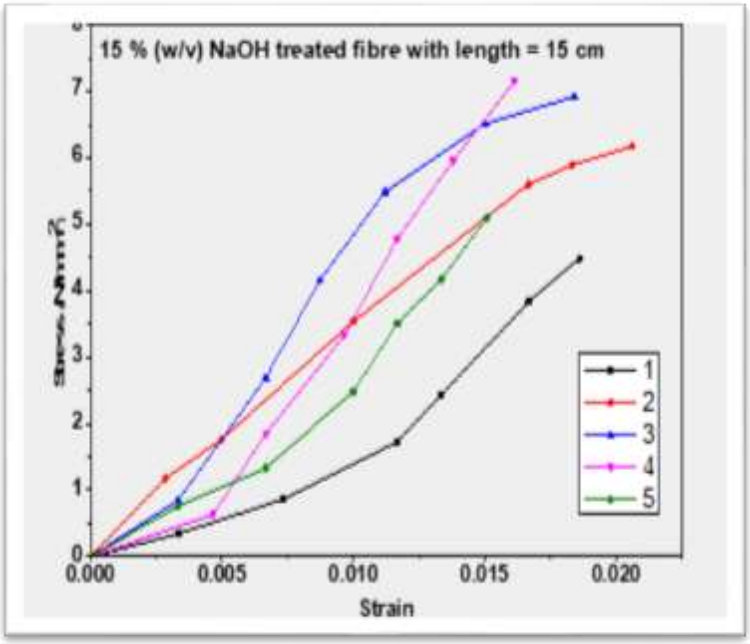

Fig.(4c) Result of 15%w/v treated OPEFB fibre@ 15 cm length

For the fibre with length 15 cm, the tensile strength values of the untreated fibre are lower than those fibres treated with NaOH solution. Similarly, the tensile strength values of fibre treated with 10 % (w/v) NaOH are higher than the untreated fibres. In much same way, fibres treated with 15 % (w/v) NaOH solution exhibited tensile strength values higher than the untreated fibres and fibres treated with 10 % (w/v) NaOH in a respectively manners.

Effect of fibre length on tensile properties of palm fruit fibre

(A) Untreated fibre

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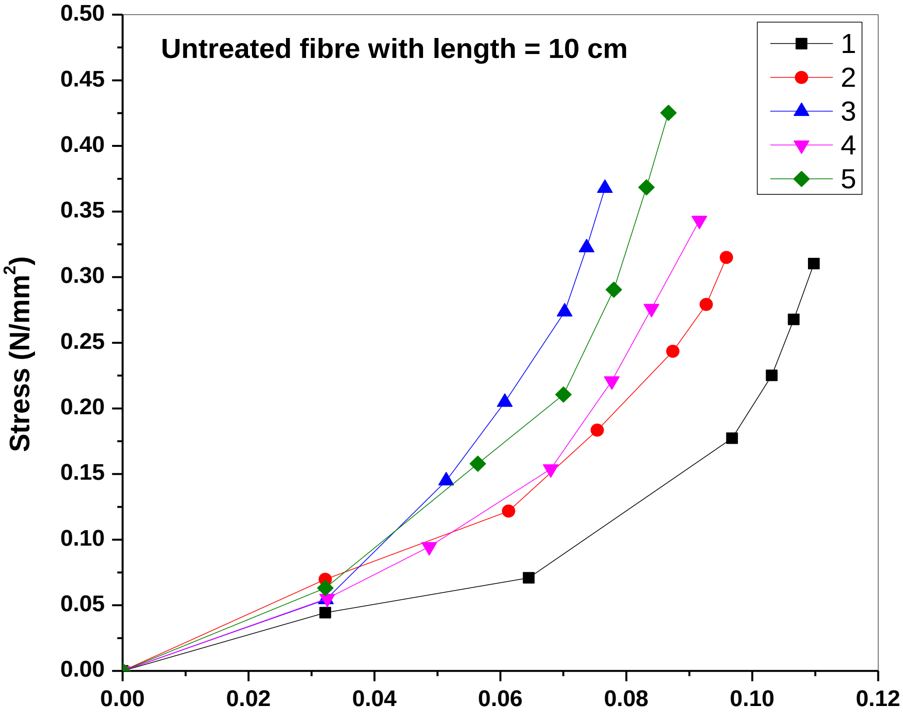

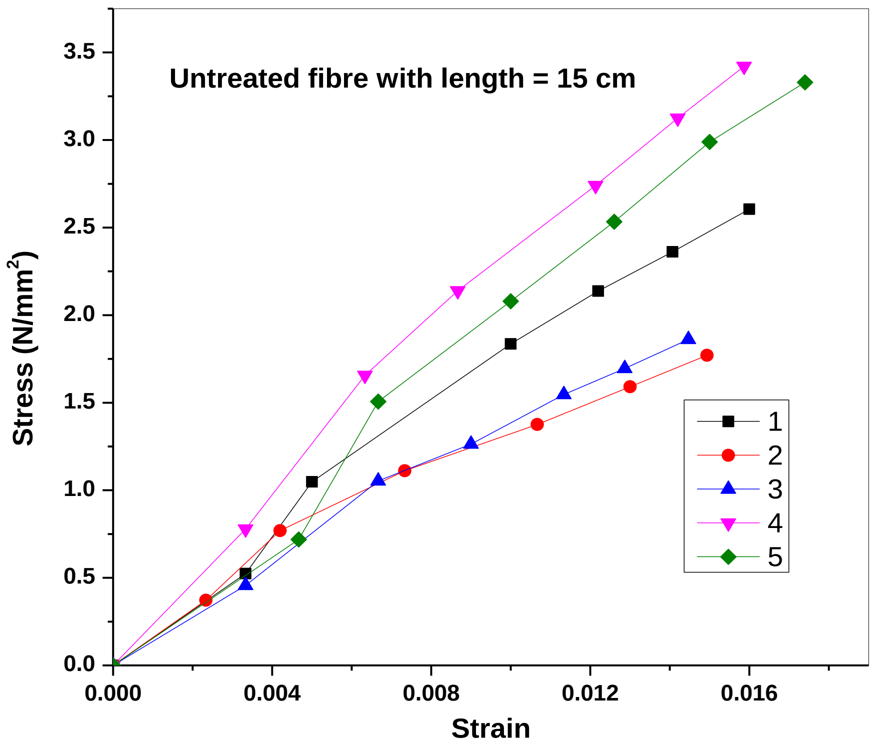

Figure (5a) Effect of fibre length on tensile properties of untreated OPEFBfibre

In figure (5a), the shapes of OPEFB fibre at the respective lengths of 100mm and 150mm were compared when both were untreated to ascertain their behaviors at different fibre lengths. The tensile strength of fibre has a drastic improveup to 89.2% increase at the length of 15cm when compared to 10cm fibre length.

(B) 10 % w/v NaOHtreatedfibre

Also when the two different lengths (@ 10 and15cm)offibre were subjected to alkaline treatment at 10% w/v concentration, they were equally found to have more than 10% increase in tensile strength.

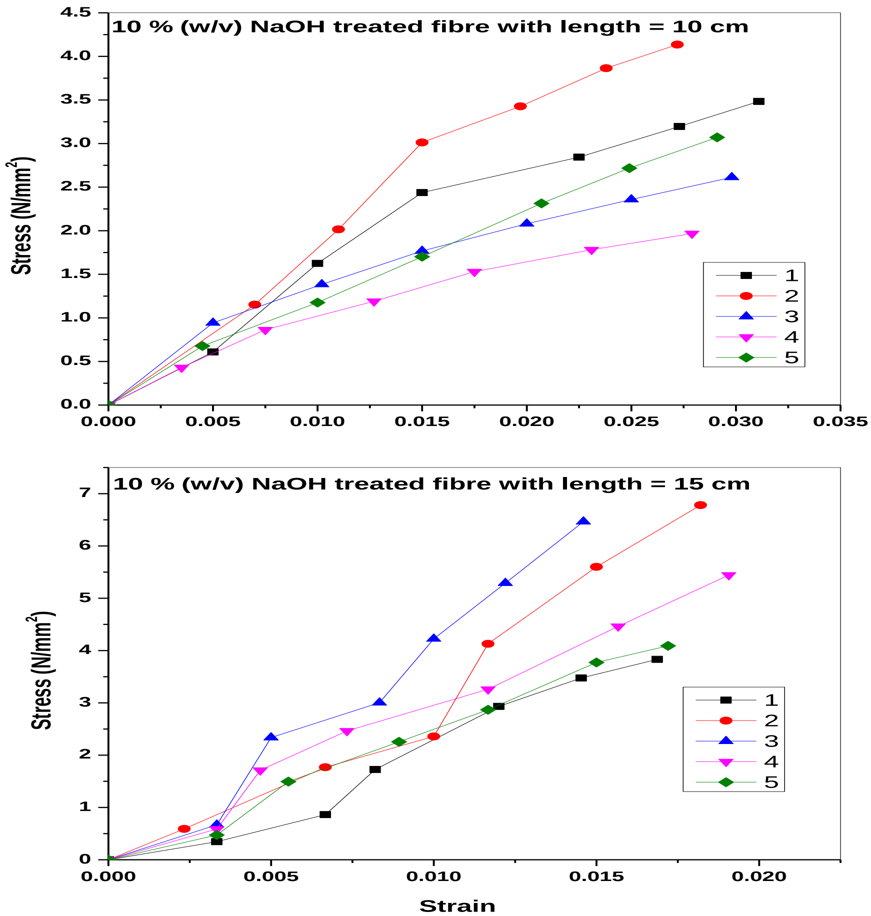

Figure (5b) Effect of fibre length on tensile properties of 10 % w/v NaOH treated palm fruit fibre

(C) 15 % w/v NaOH treated fibre

Finally, both lengths of OPEFB (10 &15cm) fibre were compared at 15%w/v of alkaline treatment, the tensile strength fibre length of 15cm was found to be greater by 5.7% which is clear evidence that fibre lengths has a greater influence on the tensile properties of OPEFB fibre.

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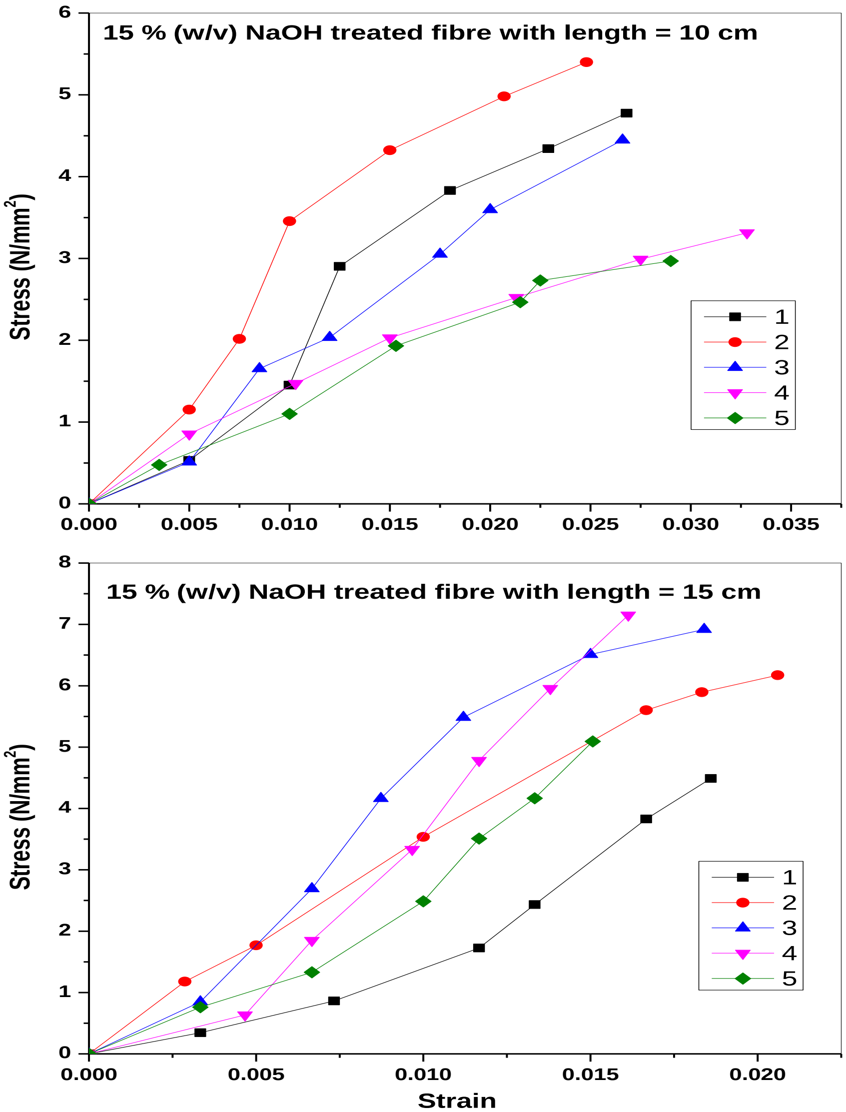

Figure(5c). Effect of fibre length on tensile properties of 15 % w/v NaOH treated OPEFBfibre

In the literature, many researchers like Witayakran et al. (2017) and others like Ramlee etal(2016), Izani et al (2013) etc. recommended NaOH solution as a chemical pretreatment that improves the tensile strength of OPEFB fibreand these was also confirmed in figure(3b) to figure(3c) and also in figure (4b) to figure(4c) for 10% and 15%w/v NaOH treatmentabove at 100mm and 150mm length of fibre respectively. Also from the literature, the report ofFu,Lauke and Mai (2019) was on a contrary because they were on a view that the higher the length of the natural fibre, the lower the tensile strength result becomes when combined with a composites. Therefore, this simply shows that the fibre at high length or size does not form a strong bond with the matrix as found by Dikobe, and Luyt, (2007). In figure(4c),the fibretreated with 15% NaOH solution at the length of 150mm recorded a lower strain values as found by Raut and Gomez, (2016).However, the lower stain valuesmaybe as a result of the breakage from over treatment of the fiber. However, the tensile strength obtained from the research differs from the literature results hence soil conditions varies from one climatic region to the other and so many other factors as reported by Witayakran et al.,(2017).Though that NaOH solution improves the tensile strength of the raw fibre, it can as well reduce the tensile strength when subjected to over-treatment which may lead to the destruction of the cellulose. As a result of that, it becomes very necessary to consider both the concentration of NaOH solution and the time of fibre treatment to avoid the damage done to the cellulose. Hence, the quality of palm trees obtained varies from one location to the other as a result of soil condition and so many other factors. Based on that, it be would be difficult to generalized both the range of NaOH solution concentration and time of treatment for all the OPEFB fibre except for palm trees from the same locality.

Conclusion

The above research on the effect of fibre lengths on the mechanical properties of OPEFB fibre has shown that fibre lengths are very important parameter that should notbe underrated when considering fibre strength parameters. The two untreated fibres at 10cm and 15cm length when subjected to tensile strength test, fibre at 15cm length gave the best result. However,for the fibre with length 15 cm, the tensile strength values of the untreated fibre are lower than those fibres treated with NaOH. Also, the tensile strength values of fibre treated with 10 % (w/v) NaOH are higher than the untreated fibres. In the samevain, fibres treated with 15 % (w/v) NaOH solution exhibited tensile strength values higher than the untreated fibres and fibres treated with 10 % (w/v) NaOH. Therefore, this condition would only hold provided the fibre was optimally treated and also the length of fibre not exceeding the tolerable limit.

Recommendation:

Intensive research should be made to enable the researchers all over the globe to close the gap in different tensile strength exhibited by different palm trees (OPEFB) fibre produced in different part of the world, when subjected to the same chemical treatment (NaOH).

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References

Abdullah, C. I., Azzahari, A. D., Mas, N., Abd, M., Hassan, A., & Yahya, R. (2019). Optimizing treatment of oil palm-empty fruit bunch (OP-EFB) fiber: Chemical, thermal and physical properties of alkalized fibers. Fibers and Polymers, 20(3), 527–537.

Akasah, Z. A., Mohd, N., Nik, Z., & Dullah, H. (2019). The influence of oil palm empty fruit bunch fibre geometry on mechanical performance of cement bonded fibre boards. International Journal of Mechanical Engineering and Robotics Research, 8(4), 547–552. https://doi.org/10.18178/ijmerr.8.4.547-552

Ayu, R. S., Khalina, A., Harmaen, A. S., Zaman, K., Isma, T., Liu, Q., Ilyas, R. A., & Lee, C. H. (2020). Characterization study of empty fruit bunch (EFB) fibers reinforcement in poly(butylene) succinate (PBS)/starch/glycerol composite. Polymers (Note: Missing full citation details like volume, issue, and pages. Please verify and complete.)

Bressiani, J., Santetti, G., Oro, T., et al. (2021). Hydration properties and arabinoxylans content of whole wheat flour intended for cookie production as affected by particle size and Brazilian cultivars. LWT, 150, 111918.

Danso, H. (2017). Properties of coconut, oil palm and bagasse fibres: As potential building materials. Procedia Engineering, 200, 1–9.

Dede, H., Ismail, B., & Fauzi, F. (2022). Enhancement of the mechanical, self-healing and pollutant adsorption properties of mortar reinforced with empty fruit bunches and shell chars of oil palm. Polymers (Basel), 1(1). (Note: Missing pages and DOI; please verify.)

Dikobe, D. G., & Luyt, A. S. (2007). Effect of filler content and size on the properties of ethylene vinyl acetate copolymer-wood fiber composites. Journal of Applied Polymer Science, 103(6), 3645–3654.

Fu, S. Y., Lauke, B., & Mai, Y. W. (Eds.). (2019). Science and engineering of short fibre-reinforced polymer composites (2nd ed.). Elsevier.

Godara, M. (2019). Effect of chemical modification of fiber surface on natural fiber composites: A review. Materials Today: Proceedings, 18, 3428–3434. https://doi.org/10.1016/j.matpr.2019.07.270

Hassan, C., &Sapuan, S. M. (2018). Effect of chemical treatment on the tensile properties of single oil palm empty fruit bunch (OPEFB) fibre. Trends in Textile Engineering & Fashion Technology, 3(2), 17. https://doi.org/10.31031/tteft.2018.03.000560

Ibrahim, M. N. (2016). Dimensional stability properties of medium density fibreboard (MDF) from treated oil palm (Elaeis guineensis) empty fruit bunches (EFB) fibres. Open Journal of Composite Materials, 6(4), 91–99. https://doi.org/10.4236/ojcm.2016.64009

Izani, M. N., Paridah, M. T., Anwar, U. M. K., Nor, M. M., & H'ng, P. S. (2013). Effects of fiber treatment on morphology, tensile and thermogravimetric analysis of oil palm empty fruit bunches fibers. Composites Part B: Engineering, 45(1), 1251–1257.

Jeyapragash, R., Srinivasan, V., & Sathiyamurthy, S. J. M. T. P. (2020). Mechanical properties of natural fiber/particulate reinforced epoxy composites – A review of the literature. Materials Today: Proceedings, 22, 1223–1227. https://doi.org/10.1016/j.matpr.2019.12.146

Kochova, K., Schollbach, K., & Brouwers, H. J. H. (2015). Use of alternative fibres in wood wool cement boards and their influence on cement hydration. In Proceedings of the 19th International Conference on Building Materials (Ibausil) (pp. 1375–1382). Bauhaus University, Weimar, Germany.

Mbeche, S. M., & Omara, T. (2020). Effects of alkali treatment on the mechanical and thermal properties of sisal/cattail polyester commingled composites. PeerJ Materials Science, 2, e5. https://doi.org/10.7717/peerj-matsci.5

Mohammad Padzil, F. N., Lee, S. H., Ari Ainun, Z. M. A., Lee, C. H., & Abdullah, L. C. (2020). Potential of oil palm empty fruit bunch resources in nanocellulose hydrogel production for versatile applications: A review. Materials, 13(5). https://doi.org/10.3390/ma13051133 (Note: Added likely DOI from MDPI based on volume/issue)

Mondylaksita, K., Budhijanto, W., Taherzadeh, M. J., &Millati, R. (2022). Characteristic of oil palm empty fruit bunch after ethanol-organosolv pretreatment catalyzed by acid. IOP Conference Series: Earth and Environmental Science, 963(1), 012054. https://doi.org/10.1088/1755-1315/963/1/012054

Omoniyi, A. (2019). Potential of oil palm (Elaeis guineensis) empty fruit bunch fibres cement composites for building applications. AgriEngineering, 1(2), 153–163. https://doi.org/10.3390/agriengineering1020012 (DOI inferred based on journal details)

Raia, R. Z., &Iwakiri, S. (2021). Effects of alkali treatment on modification of the Pinus fibers. Matéria (Rio de Janeiro), 26. https://doi.org/10.1590/S1517-707620210001.1236

Ramlee, N. A., Jawaid, M., Zainudin, E. S., & Yamani, S. A. K. (2019). Tensile, physical and morphologic properties of oil palm empty fruit bunch/sugarcane bagasse fibre reinforced phenolic hybrid composites. Journal of Materials Research and Technology, 8(4), 3466–3474. https://doi.org/10.1016/j.jmrt.2019.05.008

Raut, A. N., & Gomez, C. P. (2016). Thermal and mechanical performance of oil palm fiber reinforced mortar utilizing palm oil fly ash as a complementary binder. Construction and Building Materials, 126, 476–483. https://doi.org/10.1016/j.conbuildmat.2016.09.097

Ridzuan, M. J. M., Abdul Majid, M. S., Afendi, M., Kanafiah, S. N. A., Zahri, J. M., & Gibson, A. G. (2015). Characterisation of natural cellulosic fibre from Pennisetum purpureum stem as potential reinforcement of polymer composites. Materials & Design, 89, 839–847. https://doi.org/10.1016/j.matdes.2015.10.033

Sarukasan, D., Thirumavalavan, K., Prahadeeswaran, M., &Muruganandhan, R. (2021). Fabrication and mechanical characterization of jute-coir reinforced unsaturated polyester resin hybrid composites with various fiber size using compression moulding technique. (Note: Journal details and DOI missing – please provide or verify.)

Soh, N. M. Z. N., Akasah, Z. A., Dullah, H., Aziz, A. A., &Aminudin, E. (2018). Alkaline treatments on EFB fibre: The effect on mechanical-physical properties and fibre-cement hydration rate. Malaysian Construction Research Journal, 4(2 Special Issue), 117–128.

Sugiman, S., Setyawan, P. D., &Anshari, B. (2019). Effect of fiber length on the mechanical properties and water absorption of bamboo fiber/polystyrene-modified unsaturated polyester composites. In IOP Conference Series: Materials Science and Engineering, 532(1), 012008. https://doi.org/10.1088/1757-899X/532/1/012008

Tan, Z. E., Liew, C. K., Yee, F. C., &Talamona, D. (2017). Oil palm empty fruit bunch fibres and biopolymer composites: Possible effects of moisture on the elasticity, fracture properties and reliability. In Green Biocomposites (pp. 271–291). Springer. https://doi.org/10.1007/978-3-319-49382-4_11

Witayakran, S., Kongtud, W., Boonyarit, J., Smitthipong, W., &Chollakup, R. (2017). Development of oil palm empty fruit bunch fiber reinforced epoxy composites for bumper beam in automobile. Key Engineering Materials, 751, 779–784. https://doi.org/10.4028/www.scientific.net/KEM.751.779