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EXPERIMENTAL INVESTIGATION OF MECHANICAL AND PHYSICAL PROPERTY OF OKRO BAST FIBRE/EPOXY COMPOSITES

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Abstract – In recent years the development of polymer composites made from organic resources in the various sectors is increasing considerably due to the environmental issues and health hazard possessed by the traditional or synthetic fibres during disposal and manufacturing. Nnatural fibres are rapidly used as the reinforcement material in polymer matrix composites due to their advantages like low cost, availability, low density, good mechanical properties environment friendly, higher stiffness, and biodegradability characteristics. In present study, The OBF were treated with 5% sodium Hydroxide and then fabricated using ER as the matrix material. OBF weight fraction of 3% ,6%, 9%, 12% and 15% was used as the filler material for all the composites. Composites Preparation and testing were conducted according to the ASTM standards. Tensile, hardness, impact and water absorption were conducted to find the mechanical and physical behavior of the composites.

Keywords – Epoxy Resin, Okro bast fibre, Filler Loading.

I. INTRODUCTION

The increasing demand concerning global warming and depleting petroleum reserve has led researchers and scientists to focus on the use of natural fibers as bio-fillers in thermosetting and thermoplastic polymers. Unlike synthetic fiber, natural fibers are capable of imparting certain benefits to the composites such as low cost, high strength, low density, biodegradability, and a high degree of flexibility during the extraction of fiber and processing as stated by Sathish *et al.* (2018). The natural fibres in their quality have a positive impact on the environment and play a role in the emerging "green" economy based on energy efficiency. The use of natural fibre in composites reduced or adds value to the fibre thereby reducing the rate of carbon emission in the environment

However, natural fibres yield poor mechanical properties when used as fillers in thermoplastic or thermoset due to incompatibility between the fibre and the matrix. But with modification and advancement of polymer matrix composites, the mechanical properties tend to improve with the addition of one or more fillers in the properties of composites. Natural fibre such as Okro, flax, ramie, cotton, hemp, kenaf, sisal, bamboo, and jute are used in place of synthetic fibres as reinforcement in polymer composites. Okro (*Abelmoschus esculentus* (L.) Moench), also known as *Hibiscus esculentus* L., is a member of the mallow (*Malvaceae)* family, which includes hibiscus and cotton among other species, it can be found as a tall-growing (2m tall and has leaves 10–20 cm long and broad, with lobes ranging from 5 to 7), warm-season annual or perennial (in India and Africa) that is well suited to a wide range of soil types (Shamsulalam and Arifuzzaman, 2007) It represents the only vegetable crop in the Malvaceae family, whose products have significant use in the food sector. In several parts of the world, it is known as Okro, Quingumbo, Lady's finger, Gombo, Gumbo, Bamia, Bhendi, and Bhindi. The origin of Okro is disputable, but it seems to be native to the Abyssinian center of origin of cultivated plants, an area that includes Ethiopia, Eritrea, and the eastern part of the Anglo-Egyptian Sudan. It is currently grown throughout tropical Asia, Africa, the Caribbean, and the southern United States (Shamsulalam and Arifuzzaman, 2007. The chemical composition as well as the morphological microstructure of vegetable fibres is extremely complex due to the hierarchical organization and the different compounds present at various concentrations. The vegetable fibres are mainly composed of cellulose and non-cellulosic materials, such as hemicelluloses, lignin, pectin, waxes, and some water-soluble compounds. Lignin and pectin act as a bonding agents (Muhanti *et al.,* 2005). Cellulose 67.5 % Hemicellulose 15.4 % Lignin, 7.1% pectic substances 3.4 %, waxes, and fat 3.9 % water 2.7 % (Alam and Khan, 2007).

Arrifulzaman *et al.,* (2014), in their study observed that as the filler content of OBF increases, tensile strength, young's modulus, and flexural strength of okro bast fibre/phenol formaldehyde resin (OBF/PFR) composites increase. Results suggested that the appropriate percentage of OBF in a composite is 29%, but a larger amount of OBF would decrease the tensile strength and flexural strength of OBF/PFR composites. However, the presence of hydroxyl groups in OBF also increases water absorption and results in poor compatibility between the OBF and the hydrophobic phenol formaldehyde resin (PFR) and found that grafted hydrophobic character of OBF increases compatibility with phenol formaldehyde resin (PFR). Alkali treatment and bleached OBF are well distributed in PFR and gave higher mechanical properties of the prepared composites. The strength of natural fibre-reinforced composites does not only depend on the matrix but also the number of parameters such as fibre orientation, fibre-matrix compatibility volume weight fraction of fibres the rate of aspect ratio. To this end, the objective of the present research work is to study the effect of okro bast fibre fillers on the mechanical and physical properties of epoxy composites.

II. Materials and Method

A. EXTRACTION OF FIBRE

The Okro stems were obtained from a small farm in the Gwarzo local government area of Kano state. The fibres samples were extracted by the water retting method. The okro bark was bundled in ribbon form and was immersed in a water retting bath, little pressure was applied to the soaked bundle to ensure that the bark was fully submerged for 10 days during which the cementing materials such as pectin, lignin, cellulose, and hemicellulose must have loosened and softened. On 10th day, the retted ribbon was removed and washed with a sufficient quantity of water until the pulp is completely detached from fibres; the fibres were shredded and combed to have finer fibres. Then the fibres were dried at room temperature for fifteen days (15). After drying, the fibres were chopped into short lengths (0.5cm, 1. cm, 1.5cm, 2cm, and 2.5cm) then the fibres were treated with sodium hydroxide which was used to determine the optimum fibre length that was used for the production of the composite's samples. After the determination of fibre length, the fibre length will remain constant throughout the work.

B. ALKALINE TREATMENT OF OKRO FIBRE

I. TREATMENT OF OKRO BAST FIBRE

Sodium hydroxide solutions by weight concentration of 5%, were prepared using distilled water and sodium hydroxide. The Okro fibres were soaked in the concentrated solution of 5% sodium hydroxide at a temperature of 60oC for 2 hours with continuous stirring. After the stipulated period, the fibres were removed from the solution and rinsed with a sufficient amount of water, then each batch of the treated fibres was neutralized with 1% acetic acid and then finally rinsed with distilled water. The fibres were allowed to dry at room temperature.

Table 1. Formulation table for OBF/ER composites

S/N	OBF fillers (wt%)	ER matrix (wt%)	Total (%)
1	0	100	100
2	3	97	100
3	6	94	100
5	9	91	100
6	12	88	100
7	15	85	100

OBF= okro bast fibre ER= epoxy resin

II. SAMPLE PREPARATIONS

A. FABRICATION OF OBF/ER COMPOSITES

Short or bast fibres were used for the composite's preparation using the hand layup technique. This was achieved by mixing the various ratios of the prepared fillers (OBF) (3%,6%.9%,12%, and 15) with the epoxy to form homogenous blends. The mixing was achieved by a manual stirring method for 10 -15 minutes, then the hardener was added to the mixture. The volume ratio of resin to hardener was 2:1, and after thorough mixing with the filler, the mixture was poured onto the cavity of a glass mold of dimensions 200 mm x 100 mm x 4.00 mm overlaid with aluminium foil to serve as releasing agent. The mixture was allowed to cure at room temperature for 24 h before removal from the mould. The composites were cut based on characterizations such as rectangular strips for overall testing and dog-bone shaped for tensile tests.

B. CHARACTERIZATION OF THE COMPOSITES

The characterization of the composites was performed in line with ASTM standards for testing of materials the composites were conditioned at room temperature and then subjected to various test.

A. MECHANICAL PROPERTIES

I. TENSILE PROPERTIES

The tensile test was carried out using a tensile properties tester (YG026D Multifunctional Electronic Fabric Strength Machine) according to ASTM D638 with a maximum force of 10 KN. The sample's dimensions were 100 x15 x 4 (mm) in length, width, and thickness respectively. A cross–head speed of 2 mm/min was used. The test specimens were held in the grips of the testing machine and tightened evenly and firmly to prevent any slippage as the test commenced. The resistance and elongation of the specimens were detected and recorded by the load cell until a failure or rupture occurred. From the tensile test, tensile parameters (tensile strength (breaking point), elongation at break, and tensile modulus) were determined and recorded.

II. IZOD IMPACT TEST

The Impact test is usually carried out to determine the energy needed to initiate fracture and continue until the specimen is broken at a certain point in time. It is a test that determines the resistance of the material to impact from a moving pendulum. The Izod test is used to identify the overall toughness of a material. The procedure involves specimens made with a notch which produces stress and concentration that increases the possibility of brittle failure. The notch in the specimen reduces or minimizes plastic deformation and direct fracture of the part behind the notch. The specimen is clamped into the fixture with the notched side facing the edge of the pendulum. The pendulum is allowed to hit the specimen. The Izod impact test was performed as per ASTM D256 with a standard specimen size of 64 mm x 1.27 mm x 4 mm. Impact strength is measured by dividing impact energy in joule by the thickness of the specimen. The greater number indicates the toughness of the material.

II. HARDNESS TESTING (VICKERS HARDNESS)

The sample hardness was measured using (Vickers Hardness Tester MV1-PC, Mh-v CM. 07/2012-1329) with maximum capacity of 0.1 Kgf (150 HV) in accordance with ASTM D2240. The test was carried out at temperature (23 ± 2 ^{o}C). The specimen dimension was 30 x 10 x 4 (mm). The specimen was mounted on a specimen compartment and then the indentation point was focused thereafter five different points were indented on each specimen and the hardness values were recorded. The average of the five readings were calculated and recorded.

C. PHYSICAL PROPERTY

I. WATER ABSORPTION

Water absorption was carried out according to ASTM D570. The samples were conditioned in an oven at 45 °C for 72 hours. Then, placed inside desiccators for 24 hours and finally weighed (W1) using a metler weighing balance. The weighed samples were then immersed in a plastic container containing water for 24 hours. The samples were removed from the water, wiped with a clean cloth to eliminate moisture, then re-weighed (W2) and the process continues for thirty days.

III. RESULTS AND DISCUSSION

A. MECHANICAL PROPERTY

I. TENSILE STRENGTH

Tensile strength of a material is the maximum amount of stress a material can withstands before failure. Five (5) specimens were examined for each loading of the reinforcement as presented in figure 1.

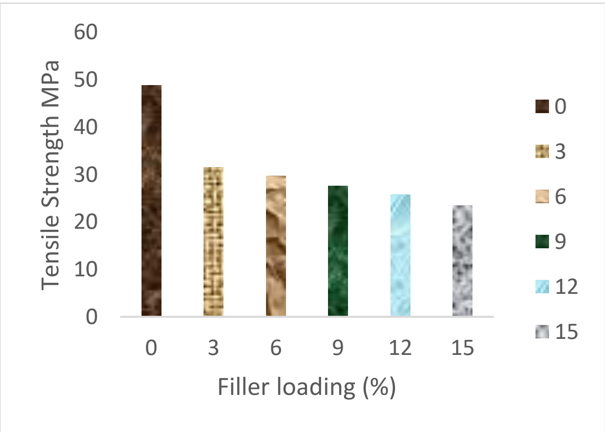

Fig 1. Tensile Strength of Untreated Okro Bast Fibre Reinforced Epoxy Resin Composites

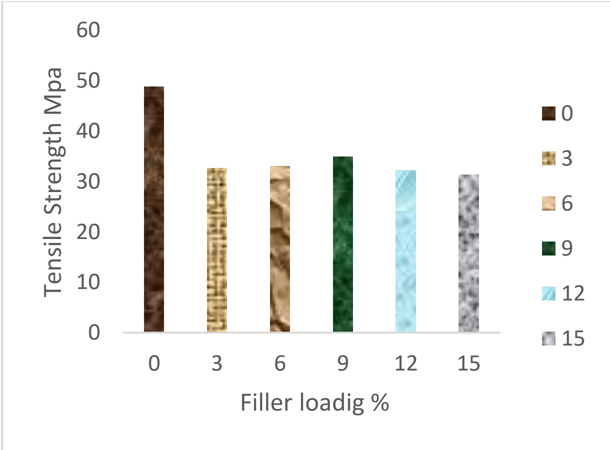

Fig 2. Tensile Strength of Treated Okro Bast Fibre Reinforced Epoxy Resin Composites

The result above shows the tensile strength of untreated and treated OBF/ER composites. It was observed that the tensile strength of untreated OBF/ER composites is lower than the control sample and some of the treated OBF composites. However, the tensile strength of the untreated fibre decreases with an increase in filler loading content of okro fibre, the observed decrease could be due to the presence of the cementing materials which leads to poor fibre matrix interfacial bond. Similar results were obtained by Sule et al., (2019) who studied the effect of alkaline treatment on the tensile, impact, and morphological properties of okro bast fibre/unsaturated polyester resin composites. They observed that values obtained for untreated OBF/UPR composites were lower that the neat resin and some treated fibre which they said may be a result of poor adhesion and non-uniform stress transfer due to fibre agglomeration in the matrix. A similar result was obtained by Ali et al., (2016) in their findings on studies of physical and mechanical properties of unsaturated polyester resin hybrid composites reinforced with jute fibre and maize cob particles.

Zin et al., 2018 also observed that the tensile strength of untreated pineapple leaf fibre is lower than the treated fibre. The alkali treatment resulted in an increasing trend of the tensile strength properties of PALF/Epoxy composites until the optimum point is reached where the tensile strength was observed to decline which could be due to excessive removal of waxy layers and lignin of the fibre in high alkaline concentration, resulting in weaker or damaged fibre. The result for treated okro bast fibre reinforced epoxy resin composites shows that the sodium hydroxide treatment has played a vital role in improving the strength of the fibre by creating a rough surface which led to better interaction between the fibre and the resin. According to Gassan and Bledzki (1999), alkali treatment interfered with hydrogen bonds in the chemical structure of the fibres, thereby increasing the fibre surface roughness, which in turn promotes the crystallinity index of fibres, enhancing the formation of hydrogen bonds between cellulose chains and chemical bonding between the fibres and the matrix of the composites.

This is in line with the result obtained by Cao *et al* (2006) in their findings on the mechanical properties of biodegradable composites reinforced with bagasse fibre before and after treatment. More so, tensile strength is affected by volume fractions, degree of adhesion between the filler and the matrix, level of dispersion of the filler and matrix, and surface-related defects. The increase in tensile strength of OBF/ER could also be due to better stirring during the production process which led to better interaction, or good interfacial bond between the fibre and the matrix. The decrease in tensile strength of OBF/ER with an increase in filler content resulted in weak adhesion between the filler and that of the matrix which accounts for the reason why the tensile strength of 12% and 15% filler loading of treated okro bast fibre were lower than the control (neat) epoxy polyester resin composites. However, at 12% and 15% filler loading weight fraction, a significant decrease in tensile strength was noticed which led to a greater possibility of weak locations in the composites which caused poor interfacial bound between the filler and the matrix at the interface when tensile forces were applied.

Similarly, the control sample has the highest value of 48.82 MPa, the values obtained from 3%,6%,9% and 15% are 32.6,33,34.6,32.2 and 31.3 MPa. The values for treated OBF/Epoxy resin composites increase with the increase in filler content to a certain level where it decreases with an increase in filler content. Hazarika *et al.*,2015 reported that alkali treatment leads to an increased fibre surface roughness because of the removal of the non-cellulosic fibre components. He further stated that a rough fibre surface improves the interlocking tendencies with the matrix, thereby resulting in the improvement of a stronger fibre matrix interfacial strength of a composite that will result in an improved mechanical property of the composite. A similar result was reported by Sugiman et al.,2019 in their research titled effects of alkali treatment of bamboo fibre under various conditions on the tensile and flexural properties of bamboo fibre/polystyrene-modified unsaturated polyester. They observed a decrease in tensile strength that could be attributed to higher filler content in the matrix that contributed to the formation of agglomerate or air entrapment during the fabrication of composites. Understandably, a good composite should have little or no voids, but unavoidable particularly in composites made through the hand-lay-up technic. Tezara et al., (2022) stated that higher filler concentrations in a matrix resulted in poor bonding between the epoxy resin (ER) matrix and the palm canal filler during tensile testing which resulted in cavities and reduce the strength of the composites. Some researchers such as Ayyavoo, Kulendran, and Anbarasu (2014) and Sudhakar, Dr. Naresh P, and Sandip (2018) reported a similar result.

B. TENSILE MODULUS

Tensile modulus is referred to stiffness of a material which is obtained by dividing the composites stress by the strain the higher stiffness value indicates reduction in ductility of a composites. The increase in modulus attributed to stiffening effects of the composites. Young's modulus may also define as tenacity, rigidity and resistance of a material to deformation it is also known as modulus of elasticity. (Bello et al.,2021)

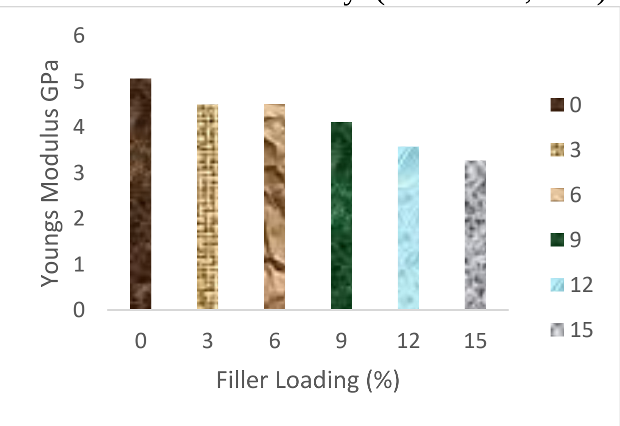

Fig 3. Tensile Modulus of Untreated Okro Bast Fibre Reinforced Epoxy Resin Composites

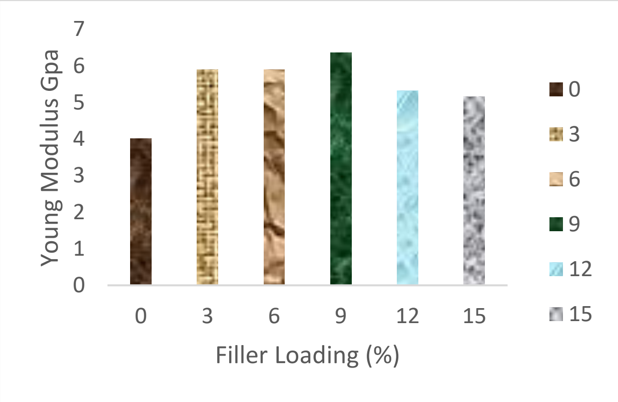

Fig 4. Tensile Modulus of Treated Okro Bast Fibre Reinforced Epoxy Resin Composite

From figure 4 above, the result showed that the modulus increased with an increase in filler loading up to about 9% filler loading for treated OBF/Epoxy composites. The maximum values for treated OBF/Epoxy composites obtained a 6.35GPa increase. As compared to the modulus of the control sample composites corresponding to 4.01GPa Epoxy resin, respectively. The incorporation of the filler (OBF) into the matrices attributed to the stiffening effect and rigidity of the composites. Nitya (2016), observed that composite structures with high modulus and high tensile strength yield more rigid structures.

Fibre treatment impacts better adhesion between the filler and the matrix which increased the stress involved to break the samples and consequently increased modulus. Composites of OBF/Epoxy modulus are higher than that of the control sample with the values of 5.90,5.9,6.35,5.33 and 5.15GPa for composites filled with 3%,6%,9%,12%,15%,18%, and 21% respectively. This increase in modulus property could be attributed to proper adhesion, compatibility, and interaction between constituent OBF and the matrix. In the work of Bello *et al.*, (2021), observed the increase in filler composition in the polymer matrix led to an increase in the modulus of the composites. However, a decrease in modulus was observed for the untreated OBF/ER composites which showed that the modulus decreases with a decrease in filler content and attains its maximum value at 6% filler loading with a value of 4.5 GPa. At 12% and 15% filler loading a remarkable decrease in modulus was noticed this may be due to uneven fibre distribution in the matrix that led to poor interfacial adhesion and an increase in the possibility of stress centers leading to premature failure of the composites. Ahmad et al.,2015 also reported that variation in the modulus observed in the various research could be attributed to the variation in the weight fractions of the fibres, matrix, and the nature of the fibres used.

According to Sair et al.,2017 their findings observed that alkali treatment improves both the tensile and modulus of hemp fibers. They also stated that the observed increase in mechanical properties of hemp fiber is due to the partial removal of hemicellulose and lignin which causes the increase in the crystallinity index of the fibres and therefore the fibre becomes more rigid. However, the removal of a certain amount of lignin and hemicellulose allows relaxation of the microfibrils and their reorganization along the principal axis of the fibre which gives rise to a more rigid structure, the increase in the percentage of NaOH eliminates the amount of lignin and hemicellulose which will create more space empty that the microfibrils reorganize. The presence of hemicellulose, lignin, and other impurities on the untreated okro bast fibre resulted in weak adhesion which in turn resulted in poor bonding between the filler and the matrix.

C. IMPACT STRENGTH

The impact strength of a material is the capacity of the composites material to resist to shock during deformation. The formed composites have moderate impact strength after the addition of the OBF into the polymeric matrix.

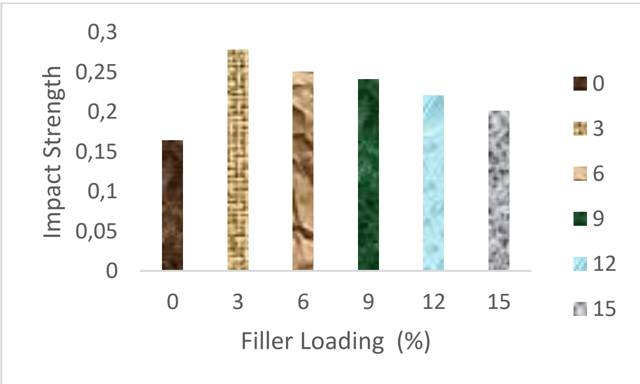

Fig 5. Impact Strength of Untreated Okro Bast Fibre Reinforced Epoxy Resin Composites.

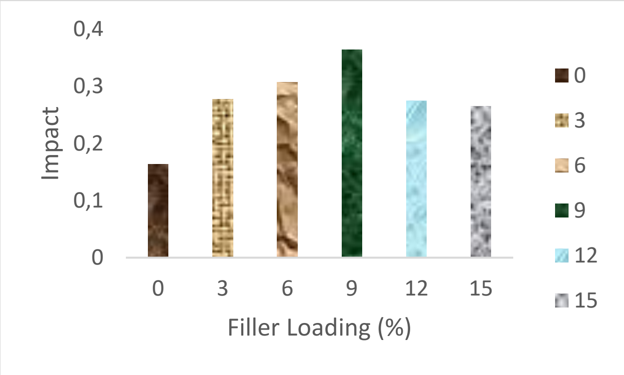

Fig 6. Impact Strength of Treated Okro Bast Fibre Reinforced Epoxy Resin Composites.

From the result above, it can be seen that a positive treatment effect was observed with the treated okro bast fibre composites compared to the untreated okro bast fibre /Epoxy resin composites. The untreated OBF/ER composites showed a decreasing trend that is the impact strength decreased with an increase in filler loading. The observed decrease could be due to poor compatibility that exists between the filler and the matrix, in addition to the voids and agglomeration of the fillers that occur with a higher percentage of fillers in the polymer matrix. However, with alkaline treatment impact strength of OBF/ER increases with an increase in filler loading. This increase may be attributed to the increase in the fibre surface roughness, resulting in better mechanical interlocking.

Suradi *et al.*, (2010) reported that the impact strength of modified oil palm fibre composites presented better and more promising results than unmodified fibre composites the impact strength of fibre this was stated in their study on Oil Palm Bio-Fibre Reinforced Thermoplastic Composites-Effects of Matrix Modification on Mechanical and Thermal Properties. The impact strength of treated OBF/ER composites shows that at 9% filler loading, an optimal impact strength was observed with a value of (0.36 j/m). But as the filler loading increases, the impact strength starts increasing at the initial stage but further decrease with the increase in filler loading. The impact strength was reduced to 0.27J/m, and 0.26J/m for OBF/epoxy at 12% and 15% with higher filler loading content, resulting in the lowest impact strength compared to other composites with 3%, and 6% filler loadings.

D. HARDNESS TEST

Hardness is the measure of wear resistance of any materials to surface indentation, which also serve as a function of stress required to produce a specific type of deformation and values obtain are used to evaluate or estimate the mechanical strength of each composite.

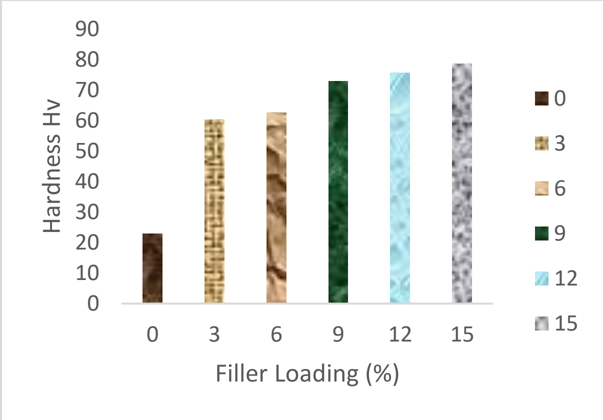

Fig 7. Hardness Value of Untreated Okro Bast Fibre Reinforced Epoxy Resin Composites.

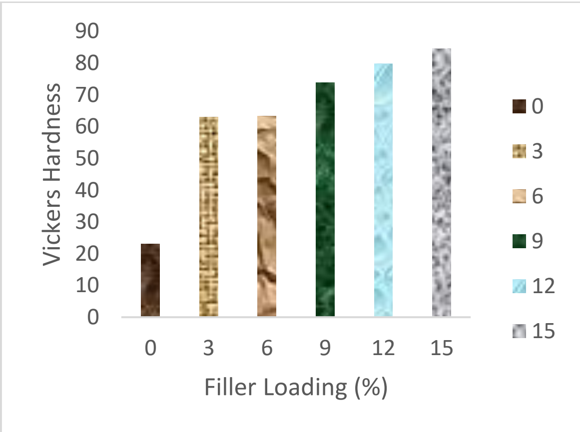

Fig 8. Hardness Value of Treated Okro Bast Fibre Reinforced Epoxy Resin Composites.

Figures 7 and 8 show the hardness values of treated and untreated OBF/UPR and OBF/Epoxy composites. It was observed that the hardness value of all the treated and untreated composites of OBF/UPR and OBF/ER increases with an increase in fibre content. Hence the highest value indicates greater resistance of the composites to indentation an increase in hardness value of treated OBF/ER composites was noticed with an increase in filler loading content with the observed values of 63 to 84.5 Hv all values observed greater than that of the control/Neat sample and the untreated OBF composites. The increase in hardness value could be attributed to the increase in stiffness and the dispersion of the fibres into the matrix, minimization of voids, and stronger interfacial bonding between the matrix and the fibre as a result of the treatment this is similar to the findings of). 15% filler loading of the treated OBF/ER exhibits the highest value. The decrease in hardness value could be attributed to poor/weak interfacial bonding between the OBF/ER composites. On the introduction of OBF into the epoxy matrix air may be trapped inside which leads to micro crack formation in the interface under loading and non-uniform stress transfer due to the fibre agglomeration in the matrix. (Sanjay et al., 2009).

The values for untreated OBF/ER are lower than that of treated OBF/ER composites. This shows that the surface modification has increased the fibre stiffness and enhanced the interfacial bonding between the filler and the polymer matrix. According to Rajeshkumar (2020), the hardness value of treated Phoenix sp. fibre was found to be higher than the untreated fibre reinforced polymer composites the observed increase could be due to the increased stiffness and enhanced interfacial bonding in the treated fibre reinforced composites he also said that when the natural fibre is treated with a higher concentration of sodium hydroxide will damage fibre leading to weak interfacial bonding between the filler and polymer matrix. A similar result was reported by Sudhakar, Naresh, and Sandip (2018) in their findings on the Study of Mechanical Properties of Bamboo fibres before and after Alkali Treatment.

E. PHYSICAL PROPERTY

I. WATER ABSORPTION

In order to find out the quantity of water absorbed by the composites; water absorption test was carried out to find out the quantity of water absorbed for 30(thirty) days. Water absorption depends on certain parameters such as matrix, fibre content/filler loading, method of fabrication and environment/ weather condition. Water absorption of treated and untreated OBF/ER composites as shown in figure 9 and 10.

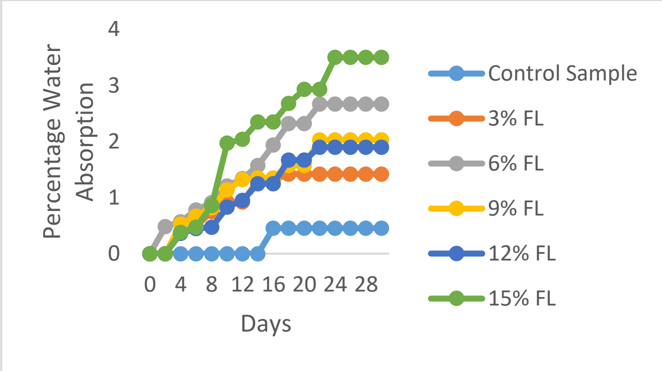

Fig. 9 Water Absorption of Untreated Okro Bast Fibre/Epoxy Resin Composites

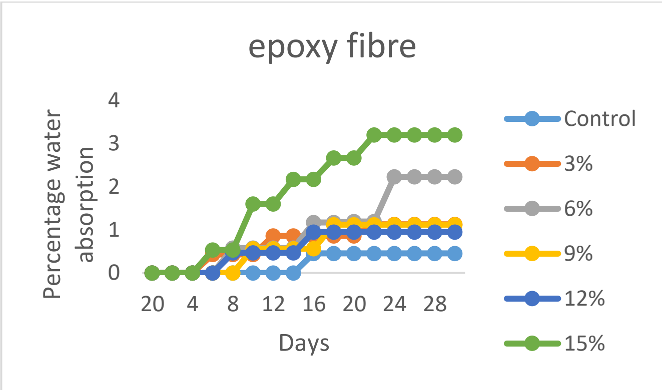

Fig. 10 Water Absorption of Treated Okro Bast Fibre/Epoxy Resin Composites

The absorption of water by the fibre may be due to the presence of hydroxyl groups which absorb water through the formation of hydrogen bonding. It could also be because natural fibre is said to be hydrophilic while polymers are hydrophobic. Both treated and untreated composites show an increment in water uptake at the beginning 48 hours and later reached a saturation point where no water is absorbed after 22-30 days with the maximum water absorption at 15% filler loading for both untreated and alkali treated OBF/ER composites. The amount of water uptake was typical of Fickian diffusion, which explains that rapid water absorption takes place at the beginning of contact of matter to water and then subsequently, a saturation point is reached. However, OBF is a natural fibre, that is hydrophilic and contains cellulose of hydroxyl groups which leads to water uptake. The low percentage of water uptake is attributed to the hydrophobic nature of epoxy resin and the effect of alkaline treatment of the OBF. The alkaline treated fibre reinforced epoxy composite shows a lower water absorption rate this is because alkali-treated fibre is less hydrophilic as the number of hydrophilic hydroxyl groups was reduced by NaOH which leads to lower water uptake from the substrate of the composite. Similar findings were reported by Madhusudhan et al., (2018

Arifuzzaman *et al.*, (2014) investigated Renewable Okra Bast Fibre Reinforced Phenol Formaldehyde Resin Composites: Mechanical and Thermal Studies, the result shows that treated OBF/phenol formaldehyde composites at 30 wt% filler loading exhibited lower water uptake, when comparison to the untreated OBF/phenol formaldehyde resin composite under the similar conditions. They stated that the phenomenon was probably due to efficient wettability of the fibre within the polymer matrix that reduced water accumulation.

CONCLUSION

Composites of OBF with Epoxy resin were produced using the hand lay-up technique. The alkaline-treated OBF/ER composites were produced and analyzed. The result shows that the addition of OBF into Epoxy resin enhances the mechanical properties of the formed composites. The hardness value of both treated and untreated composites increased with the addition of FL content, the untreated OBF/ER composites absorb more water than the treated OBF/ER composites. The tensile strength and impact strength of the treated OBF/ER composites has their highest value at 9% FL. OBF/ER composites could be used in producing materials that can find application in areas where much strength is not required. Applications like ceiling boards, and partition boards/ walls, can be the areas where OBF/ER composites can find useful applications, with the recent findings, value has been added to okro bast fibre by transforming waste OBF to wealth.

REFERENCES

Ahmad Tijjani Sule, Hindatu Umar Idris, Abu S. Lawal and Abdullahi Danladi (2016) effects of alkaline treatment on flexural strength and hardness values of Okra bast fibre /unsaturated polyester resin composites. *CARD international journal of science and advanced innovative research (IJSAIR) ISSN:2536-7315 volume1*

Ali J. B., A. Danladi and M. M. Bukhari (2015) Studies of some mechanical and physical properties of unsaturated polyester reinforced with jute fibre and maize cob particles hybrid composite *Nigerian Journal of Textiles Volume 1 No 2 www.nigeriatextiles.org.ISSN:2384-5937*

Arifuzzaman, G.M. Ahsanul, H. and Shamsu l. A. (2014) Studies on Okro Bast Fibre-Reinforced Phenol Formaldehyde Resin Composites. biomass and bioenergy;processing and properties *.doi 10.1007/978-3-319-07641-6-10*

Arifuzzaman, G.M. Shaheruzzaman, M. D, Rahman, M H. Abdur- Razzaque., S.M. Sakinul- Islam., M .D. and Shamsul Alam., M.D. (2009). Surface modification of okro fibre and its physico-chemical characteristics. Fibres and Polymers 10(1):65–70.

Ayyavoo Karthikeyan, Kulendran Balamurugan and Anbarasu Kalpana (2014) The effect of sodium hydroxide treatment and fiber length on the tensile property of coir fiber-reinforced epoxy composites *Sci Eng Compos Mater 2014; 21(3): 315–321 DOI 10.1515/secm-2013-0130*

Bello T. K., M. O. Oladipo, A. Idris, F. B. Beka, U. P. Unachukwu, A. Bukar (2021) Production of Reinforced Polyester Composite from Okra Fibre and Sawdust. *Nigerian Journal Of Technological Development, Vol. 18, No.4, December 2021*

Cao, Y. Shibata S. and Fukumoto, I. (2006). "Mechanical properties of biodegradable composites reinforced with bagasse fibre before and after alkali treatments," CompositeA.*AppliedScienceandManufacturing,Vol.37,No.3,pp.423429.doi:10.1016/j.co*

Gassan, J. and Bledzki, A. K. (1999). Possibilities for improving the mechanical properties of jute/epoxy composites by alkali treatment of fibres. *Composites Science and Technology*, 59, pp. 1303-1309.

Hazarika, S.B, Choudhury S.U, Panja S.S, Dolui S.K and Ray B.C. (2015) Natural fiber reinforced polyester based biocomposite: agro waste utilization. Journal of Scientific and Industrial Research. 74: 589 -594

Madhusudhan Reddy, B. Y. Venkata Mohana Reddy, B. Chandra Mohan Reddy (2018) Effect of Alkali Treatment on Mechanical, Water Absorption and Chemical Resistance Properties of Cordia-Dichotoma Fiber Reinforced Epoxy Composites International *Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 6 (2018) pp. 3709-3715 © Research India Publications. http://www.ripublication.com 3709*

Mohanty, A. Misra, M. Drzal, L. (2001). Surface modifications of natural fibres and performance of the resulting bio composites: an overview. Compos Interface 8:313–343

Nitya G. N. Santhiarsa 2016 Effects of alkaline treatment and fiber length towards the static and dynamic properties of ijuk fiber strengthened–epoxy composite Cite as: *AIP Conference Proceedings 1778, 030022 (2016); https://doi.org/10.1063/1.4965756 Published Online: 26 October 2016*

Rajeshkumar G (2022) Effect of sodium hydroxide treatment on dry sliding wear behavior of Phoenix sp. fiber reinforced polymer composites Journal of Industrial Textiles Vol. 51(2S) 2819S–2834S DOI: 10.1177/1528083720918948

Sanjay K. Nayak, S. Mohanty, A.K. and Sushana, K.S. (2009). Hybridization effect of glass fibre on mechanical, morphological and thermal properties of polypropylene-bamboo/glass fibre hybrid composites. *Polymer and polymer composites, Vol.18, No 4*

Sathish1s. Kumaresan K, Prabhu L, Gokulkumar S. (2018) Experimental Investigation Of Mechanical And Ftir Analysis Of Flax Fiber/Epoxy Composites Incorporating Sic, Al2o3 And Graphite, Revista Română de Materiale / *Romanian Journal of Materials 2018, 48 (4), 476 - 482*

Saira S, Oushabia A, Kammounia A, Tananea O, Abbouda Y, Oudrhiri Hassanib F, Laachachic A, El Bouaria A. (2017) Effect of surface modification on morphological, mechanical and thermal conductivity of hemp fiber: Characterization of the interface of hemp –Polyurethane composite Case Studies in Thermal Engineering *10 (2017) 550–559 http://dx.doi.org/10.1016/j.csite.2017.10.012 Published by Elsevier Ltd.*

Shamsul Alam Md. and Arifuzzaman Khan G. M. 2007 Chemical Analysis of Okra Bast Fiber (Abelmoschus esculentus) and Its Physico-chemical Properties *journal of textile and appereal technology and management Volume 5, Issue 4, Fall 2007*

Sudhakar Behera, Dr. Naresh Prasad, Sandip Kumar (2018) Study of Mechanical Properties of Bamboo fibers before and after Alkali Treatment *International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 7 (2018) pp. 5251-5255*

Sugiman Sugiman, Paryanto D. Setyawan , Buan Anshari (2019) Effects Of Alkali Treatment Of Bamboo Fibre Under Various Conditions On The Tensile And Flexural Properties Of Bamboo Fibre/Polystyrene-Modified Unsaturated Polyester Composites *Journal Of Engineering Science And Technology Vol. 14, No. 1 (2019) 027 - 047*

Sule A.T., Umar Hindatu, M.S. Mato and K.S. Abdullahi 2019 Effect of Alkaline Treatment on the Tensile, impact and morphological Properties of Okro Bast Fibre/Unsaturated Polyester Resin Composites. *African Scholar Journal of Env. Design & Construction Mgt*. (JECM-4) VOL. 15 NO. 4 ISSN: 1896-6783.

Zin M H, Abdan K, Mazlan N, Zainudin E S and Liew K E (2018) The effects of alkali treatment on the mechanical and chemical properties of pineapple leaf fibres (PALF) and adhesion to epoxy resin. *IOP Conf. Series: Materials Science and Engineering 368 (2018) 012035 doi:10.1088/1757-899X/368/1/012035*

Tezara Cionita , Januar Parlaungan Siregar , WongLing Shing, Cheng Wan Hee , Deni Fajar Fitriyana , Jamiluddin Jaafar, Ramli Junid, Agustinus Purna Irawan and Agung Efriyo Hadi (2022) The Influence of Filler Loading and Alkaline Treatment on the Mechanical Properties of Palm Kernel Cake Filler Reinforced Epoxy Composites. https://www.mdpi.com/journal/polymers. https://doi.org/10.3390/polym14153063