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Effect of Alkaline Treatment on the Tensile, impact and morphological Properties of Okro Bast Fibre/Unsaturated Polyester Resin Composites

[1]A.T. Sule, [2]I.Umar Hindatu, [1]M.S. Mato and [1]K.S. Abdullahi

[1]Department of Textile Technology and Fashion, Kano State Polytechnic, Kano
[2]Department of Art and Industrial Design, Kano State Polytechnic, Kano

Abstract

Composites of okro bast fibre with unsaturated polyester resin were produced using the hand lay uptechnique. The fibres were treated with NaOH solution of 5%, 10% and 15% concentrations, with variation in filler content. The composites were subjected to tests to evaluate their physical and mechanical properties. Tensile strength elongation and impact strength were found to increase with increase in filler content and NaOH concentration. The result obtained from scanning electron microscope indicates better adhesion for the treated OBF/UPR

Keywords: *Okro fibre, unsaturated polyester resin, tensile strength, impact, and scanning electron microscope.*

Introduction

Natural fibres (such as jute, hemp, sisal, palm, kenaf, ramie,luffa and flax) are utilized as fillers or reinforcing material for polymer-based matrices. Natural fibre are eco-friendly, light weight strong and low cost and can be used in a polymeric matrices to reinforce and achieve desired properties such as impact strength, stiffness, low density sound damping and texture together with eco-friendly characteristics in composites. This also decreases the amount of waste disposal problems and enhances reduction in environmental pollution [9].

Most bast fibres are characterized by fines and flexibility, and they are quite strong and are widely used in the manufacture of ropes and twines bagging materials and heavy-duty industrial fibres. [1]

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, warm-season annual or perennial (in India and Africa) that is well suited to a wide range of soil types. [6].

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, and Lady's finger, Gombo, Gumbo, Bamia, Kubewa,and Bhendi. The vegetable fibres are mainly composed of cellulose and non-cellulosic materials, such as hemicelluloses, lignin, pectin, waxes, and some water-soluble compounds. The lignin and pectin act as bonding agent (Muhanti *et al.,* 2005).The origin of Okro is disputable, but it seems to be native to the Abyssinian centre 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 southern United States. [6].Okro can grow up to 2m tall and has leaves 10–20 cm long and broad, with lobes ranging from 5 to 7. It has white or yellow petals that constitute the flowers of diameters in the range of 4–8 cm that are often characterized by a red or purple spot at the base of each petal. The seeds are contained in a capsule up to 18 cm long that shows 4 to 10 distinct ribs or ridge. The immature young seed pods are the edible part of this plant. Most okro cultivars produce green pods, but a few varieties produce yellow or dark red pods. These pods are harvested when immature and high in mucilage, generally within 2–6 weeks after flowering. In some countries the most interesting part of okro plant is represented by the seeds, which yield edible oil with a pleasant taste and odor, and high in unsaturated fats such as oleic and linoleic acid. [6].

De Rosa *et al*., 2009, in their study observed that the cross-sectional shape of okro fibre shows a polygonal shape that varies from irregular to a circular shape. Their diameter also varies in the range of about 40-180μm. each ultimate cell is roughly polygonal in shape with a central hole, or lumen like other natural plant fibres. The cell wall thickness and lumen diameter vary typically between 1 to 10μm and 0.1 to 20 μm respectively. The considerable difference of the diameter values of the single fibre, lumen, and their rough shape strongly affects the mechanical and dimensional properties of okro fibres. The chemical composition okro bast fibre,has being studied and in table 1.

Table1: Chemical composition of okro bast fibre,

Hemicellulose	15.4%
Lignin	7.1%
Pectic matter	3.4%
Fatty and waxy matter	3.9%
Aqeous extract	2.7%

Methodology

Okro Fibre Extraction

The okro bark was in bundled ribbon form and immersed in water retting bath , little pressure was applied to the soaked bundle to ensure that the bark were fully submerged for a period of 10 days during which the cementing materials such as pectin, lignin, cellulose, and hemicelullose must have loosen and soften. On 10th day the retted ribbon was removed and washed with sufficient quantity of water untill the pulp was completely detached from fibre, the fibres were shredded and combed to have a finer fibre. Then the fibres were allowed to dry at room temperature. After drying, the fibreswere chopped into short length (5-10mm) which was used in this work for fabrication of the composites.

Fibre treatment

Sodium hydroxide solution by weight concentration of 5%,10% and 15%were prepared using distilled water and sodium hydroxide .the fibre were soaked in the solution for a period of thirty minutes with continuous stirring .it was later removed from the solution and rinsed with water, then neutralized with 1% acetic acid and then finally rinsed with distilled water.

Preparation of the Composites Sample

Short okro fibre reinforced unsaturated composites were prepared by hand-lay-up method. The calculated amount of unsaturated polyester resin, accelerator (COBALT) and catalyst(MEKP) were weighed out and thoroughly mixed. The corresponding amount of okro fibres were weighed out and added to the UPR it was thoroughly mixed to ensure even distribution of fibres. The mixture was then poured in to a mould in a glass mould (200 x 120x80 mm) which foil paper has been laid for ease of removal of the fabricated composites. Similar procedure was used to prepare composites of different fibre loading of 5%, 10%, and 15%wt of fibre for both treated and untreated okro fibre. The fabricated composites were allowed to cure under laboratory conditions before subjecting them to morphological, physical and mechanical analysis.

Characterization of Composites

Tensile Testing

Tensile strength and elongation at break were carried out using Type Mosanto Tensometer machine at the department of MECH. ENG. ABU, Zaria.The test was performed according to ASTM D638. The test samples where clamped between the upper and lower jaw of the tensometer and the machine was started.The sample was stretched gradually with application of force until it reaches the breaking point.

Reading of maximum load and elongation at break were taken accordingly. The test was repeated Three (3) times for each of the composites and the average values were recorded. The result is shown in figures 1 and 2 respectively.

Impact

The impact test was performed according to ASTM D256 standard using Cat Nr.412 Charpy Impact Testing Machine 15joules capacity. The composites samples were cut to a length not more than 10cetimeter and a uniform width, the sample was placed on the machine and held tightly with the aid of knots, the ends are observed to be of equal length and a hammer of 15joules capacity was raised and then released to hit the sample. Work done on breaking the samples was recorded, test was repeated three times and an average was recorded.

Scanning Electron Microscopic Analysis

The composite samples were analyzed using Phenon SEM Machine Pro X model 10 KV the composites are not conductive to make it conduct conductive ,samples surface were coated with 5mm of gold using a sputter machine .the coated samples was placed on a sample holder and placed into the machine column then viewed through a navigating camera however ,adjustment was made before transferring into the electronic code .Viewing voltage was set using 10KV,magnification were increased and the sample morphology were stored in the electronic mode .the machine setting was changed from electronic mode to navigation camera before ejecting the samples from the machine.

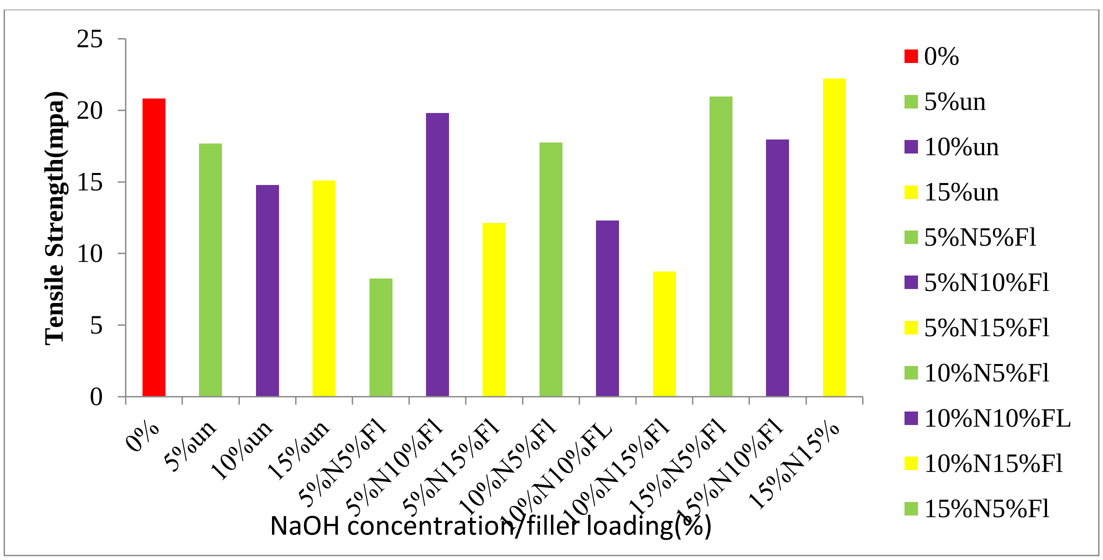


Figure1. Tensile strength of treated and untreated OBF/UPR composites

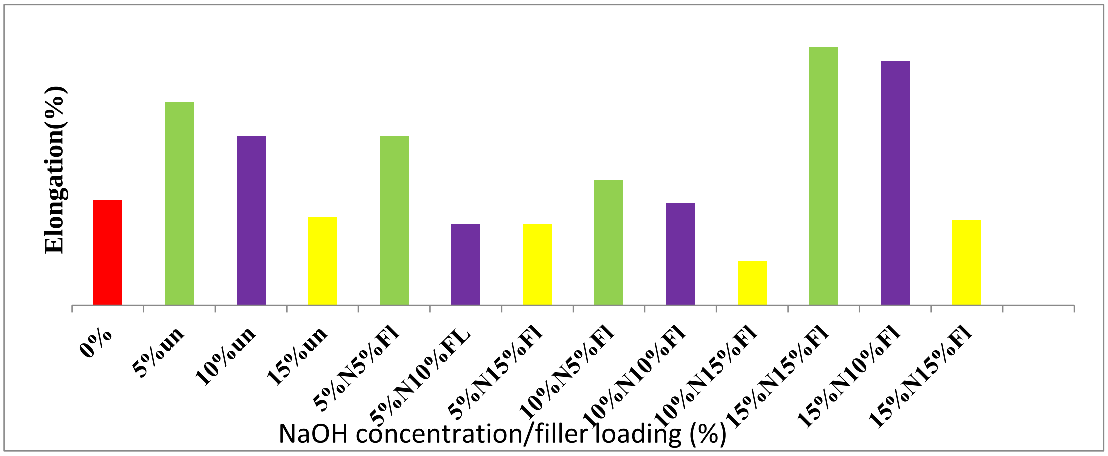


Figure 2: (%) Elongation versus filler loading of treated and untreatedOBF/UPR

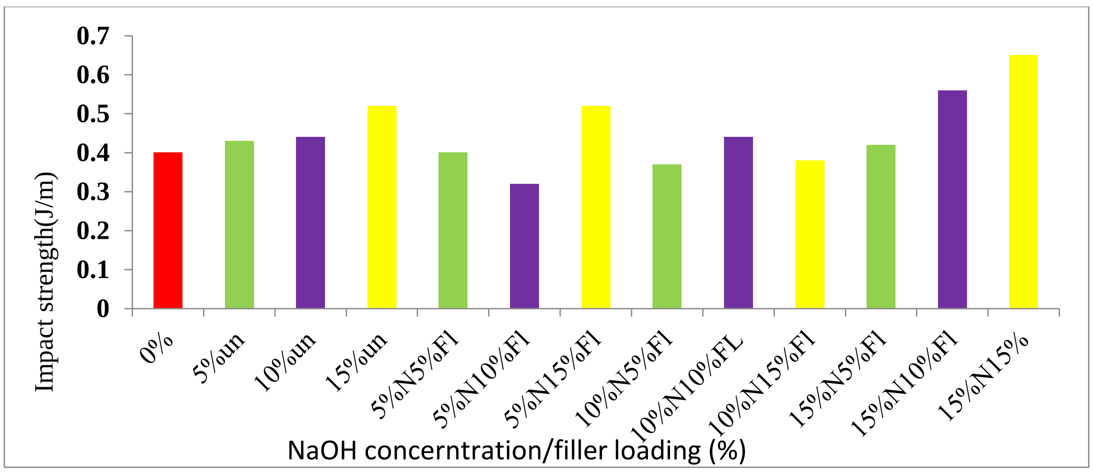
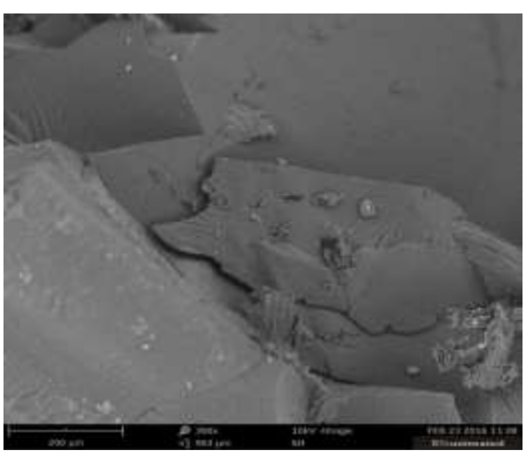
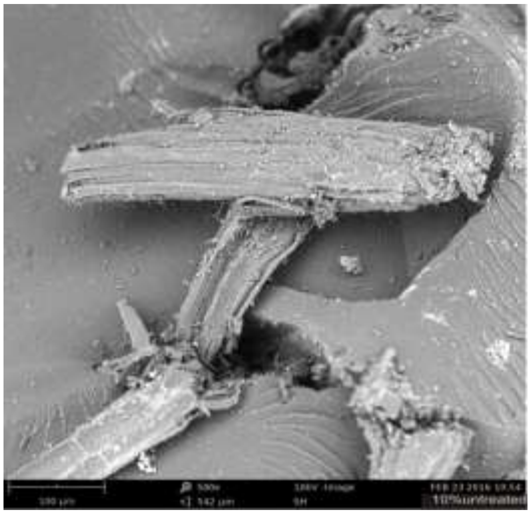


Figure 3: %Impact strength versus filler loading of untreated okro fibre/unsaturated polyester resin composites.

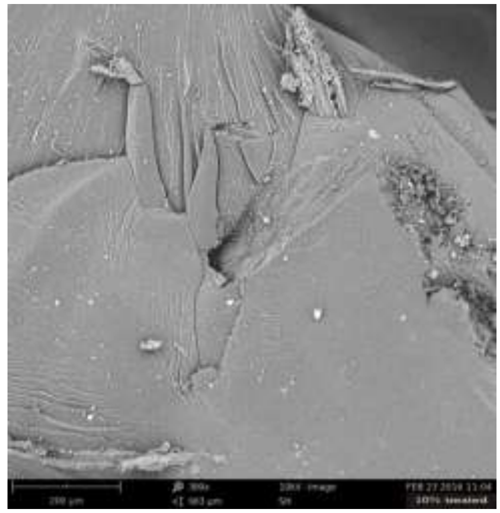


5% UTOBF/UPR Composites

5% TOBF/UPR Composites



10%UTOBF/UPR Composites



10%TOBF/UPR composites

Results and discussions

Tensile strength

Figure 1 shows that there is an increase in tensile strength at 15% alkali treatment and 15% filler loading with a value of 22.21Mpa, which is greater than all the samples .The maximum tensile strength for treated okro bast fibre /unsaturated polyester resin composites indicate that the alkali treatment has improved the adhesive characteristics of the fibre surface by removing the natural and artificial impurities there by producing rough surface topography. The treatments also leads to fibre fibrillation i.e. that is breaking down the fibre bundles into smaller fibres, this also increase the chance of effective surface area to be available for contact with the matrix.[11].A decrease was observed for 10% alkali treatment and the filler content of 5% to15% corresponding to17.86 to 8.74Mpa as show in figure 1respectively. There was similar observation for 5% alkali treatment at 5 to 15% filler content with a decrease corresponding to 19.82 to 8.25Mpa. The observed decrease could be attributed to improper fibre wetting due to increased tendency of fibre entanglement with increasing short fibre as well as the possibility of increasing fibre-rich and/or matrix-rich areas within the composite [12].

It was also observed that values obtained for the untreated okro bast fibre / unsaturated polyester resin composites is lower than that the control sample and some treated okro bast fibre/ unsaturated polyester resin composites values obtain are 17.64,14.79 and 15.09Mpa.The observed decrease in strength of the untreated okro fibre UPR composites could be attributed tothe presence of the cementing material which lead to poor fibre/ matrix adhesion, and could also be due to micro cracks formation at the interface under loading and non uniform stress transfer due to fibre agglomeration in the matrix[10].

Percentage elongation

figure 2 shows the effect of alkali treatment and filler loading on elongation of Okro bast fibre/UPR composites .The composite resulting from the 15% NaOH treated fibre exhibited the highest elongation at break and high ductility, corresponding to 17% which was higher than that of the control, untreated and some of the treated, Okro bast fibre composites. The values obtained for 5% NaOH were 12.5%, 6% to 6% and 9.25%, 7.5% to 3.35% for 10% alkali treatment. The untreated OBF/UPR composites have its highest elongation at 15% and later dropped to 6.5%. The increase of filler loading in the matrix(UPR)resulted in stiffening and hardening of the composites which reduced its ductility and led to lower elongation property, so also the reduction in elongation at break indicates the incapability of the filler to support the stress transfer from the matrix to the fibre. The enhanced elongation on treatment was due to the fact that more hemicelluloses are removed from the fibre as a result of treatment, which provided more surface roughness, hence giving rise to better interlocking with the matrix [7]

Impact strength

Figure 3 above shows that there is significant increase in impact strength at 15% NaoH treatmentwith increase in filler loading and sodium hydroxide concentration. showing the observed values (0.42 (j/m),0.56(J/m)and 0.65(J/m)), The increase in impact strength is due to reinforcement effect imparted by the fibres, which allowed stress distribution from continuous polymer matrix to dispersed fibre phase as established (Colom *et al.,* 2003).However, there was a decline in impact strength of 5% alkali treated OBF/UPR from 0.4J/m to 0.32J/m and further increase to 0.52J/m and for 10% alkali treatment there was a slight improvement from 0.37 to 0.44J/m and later decline with increase in filler loading content .The decline observed could be due to poor wetting of the fibre with the matrix, this will in turn lead to composites with weak interface [8] for 10% alkali treatment. The untreated OBF/UPR show similar trend with the 15%alkali treated OBF/UPR with 0.43 J/m, 0.44J/m and 0.52J/m respectively. It has been reported that the impact strength of a composite is influenced by many factors including the matrix fracture, fibre/matrix de bonding and fibre pull out (Obasi *et al.,* (2007).The 15% treated OBF/UPR composites showed an improvement of the impact strength compared to the untreated OBF/UPR composites.

The treatment of the OBF/UPR improves the compatibility and promotes the ability to dissipate energy during fracture of the composites.

Scanning electron microscope

Morphology studies of okro bast fibre reinforced unsaturated polyester resin revealed that the use of alkali treated fibre has lead to better adhesion between the matrix and the fibre in Fig 4.b,and d above indicating good wetting and strong interface. The evidence for the same is provided from the matrix traces seen on the surface of the fibre. Very little fibre pull out suggests that the matrix has been efficient in holding on to the fibres. This indicates that the composites have higher degree of fibre orientation under the stress, which results in higher fibre efficiency factor and hence improved mechanical strength. The okro fibres protruding from the composite indicate the degree of fibre pull out and crack deflection. The fibre surfaces that protrude are not clean with some adhering matrix material on it further indicating that the fibres are well adhered to the matrix. For the untreated fibre loaded with 5% wt okro fibre composites shows fibre breakage, fibre pull out and voids or air entrapments which, is as a result of poor interfacial bonding between the fibre and matrix.

Conclusions

Alkaline treated Okro bast fibre/unsaturated polyester resin composites were produce and analyzed. The result shows that useful materials could be produced from OBF. The tensile strength andimpact strengthhave their highest value at 15%NaOH treatment while 5%and 10% NaOH have moderate values. The use of Okro bast fibre in composites material can be used to produce material that can find applications in areas where strength is not required. Applications like celling board,partition board/ walls, can be the areas where OBF/UPR composites can find useful applications, hence adding value to okro bast fibre.

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