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Fabrication and Properties of Okro Bast Fibre/Unsaturated polyester resin Composites

U.I Hindatu[a], A.T Sule[b], K. S Abdullahi[b], M. S Mato[b]
[a] Department of Art and Industrial Design School of Technology, Kano state Polytechnic
[b] Department of Fashion and Textile Technology, School of Technology, Kano State Polytechnic, Kano
Email: amirgetso@yahoo.com; Corresponding Author: A.T. Sule,

ABSTRACT
Composites of Okro bast fibres (OBF) unsaturated polyester resins (UPR) were fabricated using hand layup technique. The composites were subjected to tests to analyze their physical and mechanical properties. The density was found to decrease from 1.14 to 0.12 g/cm3 as the fibre content increased from 0 to 15%. Water absorption showed increase with increase in filler content and with increase in the number of days in water. The result obtained from the tensile strength, elongation and hardness, of the composites were all found to decrease with increased fibre content .The scanning electron microscope showed fibre pullout and cracks at the interface.
Keywords Okro bast fibre, unsaturated polyester resin, Water absorption, Hardness, scanning electron microscope and composites.

INTRODUCTION
Composite is a combination of two or more materials that results in better properties than those of individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The two constituents are reinforcement and matrix. The properties of the composites are strong, lightweight, corrosion resistant, wear resistant, and attractive in appearance. Many composites have been developed with various types of synthetic fibres in order to improve the mechanical properties. Currently, the type of composite tends to change from composite with synthetic fibres to natural fibres. This is because the composite with synthetic fibres such as glass fibres are not environmentally friendly, lead to problems of waste glass fibre, which cannot be decomposed by nature [6]. Composites with natural fibres have many significant advantages over composites with synthetic fibres such as low cost, lighter weight, available in the form of plants or waste, non-toxicity, and does not cause skin irritation [7] The convenience of these composites lies in the fact that, the ingredients are obtained easily from natural or agricultural wastes and hence the composites can be made relative easily.

Natural fibres can be cultivated so that its availability is sustainable. However, natural fibres have many weaknesses such as irregular dimensions, stiff, susceptible to heat, easy to absorb water, and quickly obsolete [6]. Ideally composite materials used in structures where strength to weight ratio into consideration [4]. Attempts have been made to use natural fibre composites in non-structural application. Formally, numbers of automotive components were made with glass fibre composites which are now being manufactured using environmentally friendly composites. The use of natural fibres in automotive has two advantages, namely vehicles become lighter, which means improved fuel efficiency, and improved the sustainability of production because it can be cultivated [17]. Natural fibres such as sisal, jute, hemp, flax, banana, coir and palm can be used as reinforcement in a polymeric matrix composite to achieve this aim [12]. Natural fibre composites made of renewable agricultural product can represent a suitable alternative to traditional glass fibre reinforced composites and Add value to source of income to the agricultural community In order to optimize the composite properties, a detailed investigation of the mechanical and physical properties of natural fibres is needed.

Okro plant OBF belongs to the species 'esculentus', in the family 'malvaceae'. It is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. The fruits are harvested when immature and eaten as a vegetable. The vegetable can be collected from plant up to the period of 3–6 months. The plant was then subject for direct combustion. This operation causes not only environmental pollution but also waste valuable fibre components. The chemical composition of OBF is α-cellulose (60–70 %), hemicelluloses (15–20 %), lignin (5–10 %) and pectins (3–5 %) along with trace amount of water-soluble materials [1]. Though it contains higher percent of cellulose, it may have potentiality to make good-quality composite with thermoplastic/ thermoset resins. [3]. Thermoset resins are promising materials for natural fibre composite industries because they are insoluble and infusible and have high-density networks. A number of studies have been reported on thermoset-plastics-natural fibre composites.

METHODOLOGY

Okro Fibres Extraction

The Okro stem was obtained from a small farm in Gwarzo local government area of Kano state. The fibres were extracted by water retting method. The okro bark was bundled in ribbon form which was 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 softened. On 10th day, the retted ribbon was removed and washed with sufficient quantity of water untill the pulp was completely detached from fibres; the fibres were shredded and combed to have finer fibre. Then the fibres were allowed to dry at room temperature. After drying, the fibres were chopped into short lengths (5-10mm) which was used in this work for fabrication of the composites.

Preparation of the Composites Samples

Short Okro bast fibre reinforced unsaturated composites were prepared by hand-lay-up method. Unsaturated polyester,methyl ethyl ketone peroxide (MEKPO) and cobalt were used as matrix components. Polyester and hardener 1% volume were mixed in a container and stirred to form matrix. Then the short Okro fibres were poured gradually and stirred well to form a homogeneous mixture. The mixture was then poured into a glass mould of (200 x 120x80 mm) on which foil paper has been laid for ease of removal of the fabricated composites. The composites with the variation of fibre weight fraction 5%, 10% and 15% were made. The fabricated composites were cured 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.

Hardness Testing (Rockwell Hardness)

The Indectec Universal testing Mechine Model 8187.5 LKV B Rockwell hardness HRF indentor (1/6") steel ball with minor load 10kgf and major load 60kgf was used in measuring the hardness of the samples according to ASTM 2240 .The sample with parallel flat surface was placed on the avail of the apparatus) and lowering the steel ball onto the surface of the sample .The dial was adjusted to zero on the scale under minor load (10kg) and the major load (60kgf) was immediately applied by releasing the trip lever .After 15 second the major load was removed and the specimen was allowed to recover for 15 second the test was repeated three times and an average of each test result was recorded .

Water Absorption

Water absorption was carried out according to ASTM 2842 thirteen (13) samples were cut to a rectangular shape and size (2x2cm) and weighed using digital weighing balance. The weighed samples were placed in a plastic container and enough water was added so that would be completely immersed, the composites samples were left in water for 48 hours. The samples were removed from the water, wiped with a clean cloth to eliminate moisture, and then re weighed and the process continues for thirty days. The percentage water absorbed was calculated using Equation

$$percentage\ water\ absorption = \frac{final\ weight - initial\ weight}{initial\ weight} \times 100$$

Density

The weight of the test sample was measured after which it was submerged in to a known volume of water. The volume of the water displaced was recorded; densities of the composites were determined according toASTMD792-13. The densities of the composites were then determined using the equation below in grams per centimeter cube (g/cm3).

$$\rho = \frac{m}{v}$$

Scanning Electron Microscopic Analysis

The composite samples were analyzed using Phenon SEM Machine Pro X model 10 KV, using the tensile fractured surface. The fractured surface were coated with 5mm of gold

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using a sputter machine ,the coated samples was then placed on a sample holder and 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.

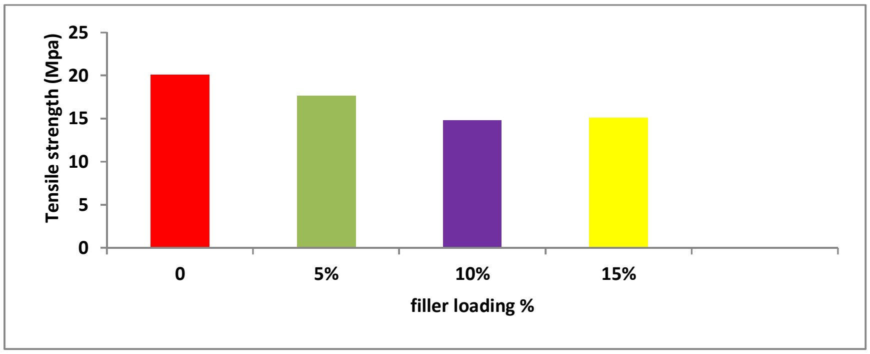

Figure 1: Tensile strength against filler loading of OBF/UPR composites

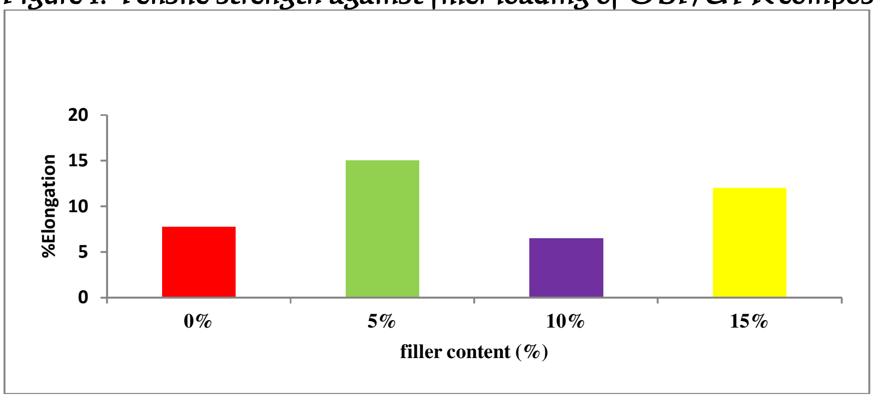

Figure 2: Percentage elongation against filler loading of OBR/UPR composites

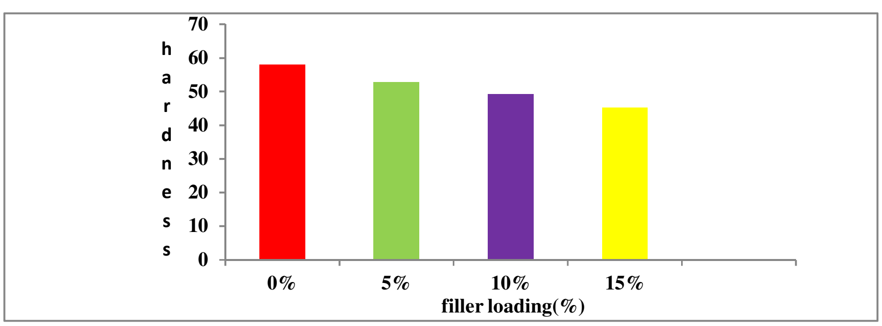

Figure 3: Hardness against filler loading of OBF/UPR Composites

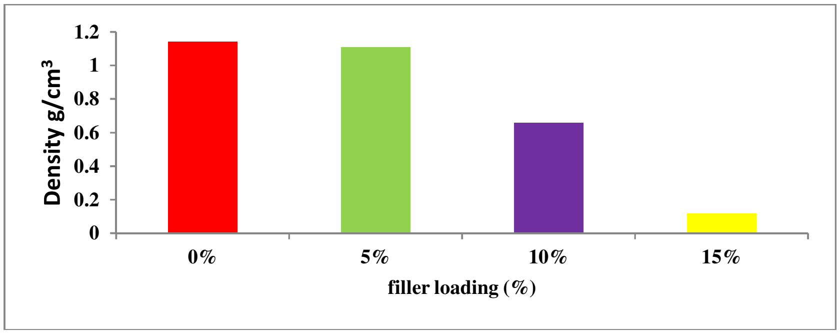

Figure 4: Density against filler loading of OBF/UPR composites

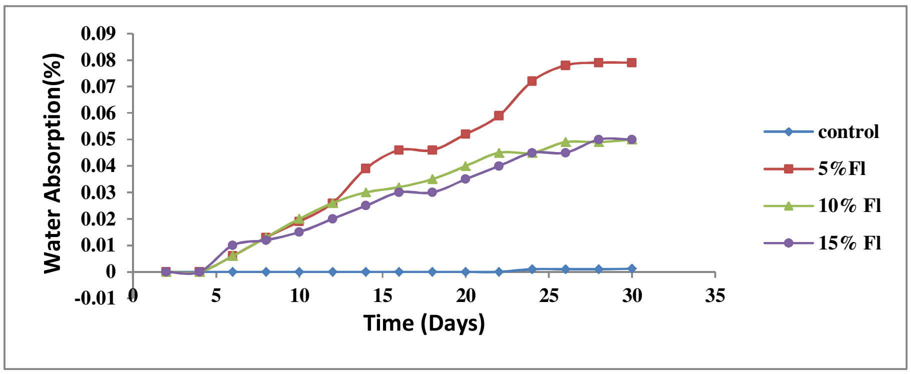

Figure 5 :(%) water absorption against filler loading of OBF/UPR

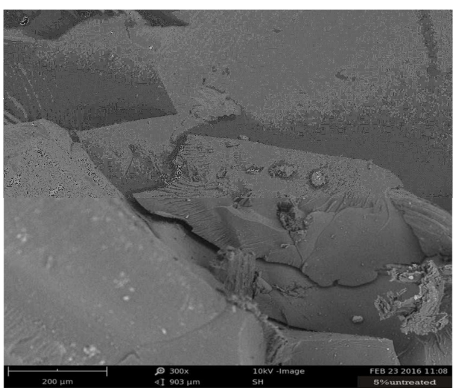

plate1: 5%OBF/UPR Composites

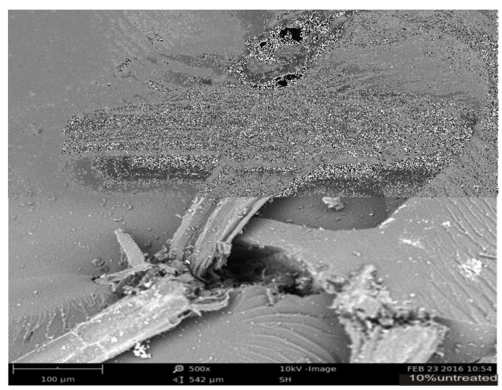

Plate 2:10%OBF/UPR Composites

DISCUSSION OF RESULT

Tensile strength

figure 1 shows the tensile strength of OBF/UPR composites, it was observed that tensile strength decreases with increase in filler content having the values of 17.64, 15.09 and 14.79Mpa.The observed decrease in strength of the okro bast fibre/ UPR composites could be attributed to poor fibre/ matrix adhesion which leads to micro cracks formation at the interface under loading and non uniform stress transfer due to fibre agglomeration in the matrix [8].

Percentage elongation

The percentage elongation decreased with increase in filler loading content for all the composites samples, 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. However the reduction in elongation at break indicates the incapability of the filler to support the stress transfer from the matrix to the fibre. Such reduction in elongation at break of polymer composites with increase in filler content, irrespective of filler size has been reported by [9].

Hardness

It was observed that the hardness value decreases with increase in filler loading having the values of 52.8, 49.2 and 45.2HRF, which is similar to density. The decrease in hardness value could attribute to poor/weak interfacial bonding between the okro fibre and the unsaturated polyester resin matrix. This is similar to the result obtained by [2].

Density

The density of all the composites decreases with increase in filler loading. This is due to low density of the fibre than the matrix thereby resulting in composites with low density [12]. Natural fibres have the advantage of having light weight, which proves density decreases with increasing fibre content this is similar to the result obtained by[2] in their study of fabrication and properties of pineapple fibres /high density polyethylene composites.

Water absorption

It was observed that the unreinforced sample composite (Control sample) absorbed the minimum amount of water due to its hydrophobic nature and on reinforcing it with the okro fibres, the ability to absorb moisture increased as a result of the introduction of the hydrophilic okro fibres. It was also observed that percentage water absorption increases with increase in filler content. The rate of water absorption depends on the internal material states, nature of reinforcements, fibre matrix interface and environmental factors such as temperature and applied stress. Natural fibres contain artificial and natural impurities and larger amount hydroxyl group in cellulose of the fibre which makes it hydrophilic in nature when used as reinforcement in a polymeric matrix. This result in poor interface and poor resistance to moisture absorption [5]. The low moisture uptake of the composite could be attributed to the improved interfacial adhesion that reduced water accumulation in the interfacial voids and prevents water from entering the composite [14]. The increasing moisture absorption might be attributed to the inability of the matrix material to completely saturate the fibre at higher fibre length as reported by [13].

Scanning Electron Microscope

From plate 1 and 2, it was observed the presence of okro bast fibres protruding from the composite indicate the degree of fibre pull out and crack deflection. This could be attributed to fibre pull out and voids or air entrapments which, is as a result of poor interfacial bonding between the fibre and matrix [15]

CONCLUSIONS

OBF/UPR composites produce and tested show that useful materials could be produced out of the OBF. The composites have low density values, which is one of the major requirements of composites materials. The hardness values are moderate, while tensile strength values are on the low side. With the abundance of Okro fibres and unsaturated polyester resin, other useful materials can be produced out these materials which can find applications in areas where strength is not the prime factor. Treatment of the OBF can be made to improve the interfacial adhesion between the OBF and UPR as this will improve the mechanical properties of the composites. Applications like partition boards, ceiling boards, and shoe rags can be areas where OBF/UPR composites can find useful applications, and value has been added to OBF.

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