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Surface morphology and mechanical properties of *Luffa cylindrical* with polystyrene composite blends

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ABSTRACT

Surface modification of *Luffa cylindrical* natural fiber was done to improve its mechanical properties. Infrared (FTIR), flextural strength, scanning electron microscope (SEM) and water absorption tests of the composite were carried out using polystyrene to provide composite blends in the ratio of 90/10, 80/20, 70/30, 60/40 50/50. 80/20 treated composite had the highest strength-mechanical test, followed by 60/40 treated and then the 50/50 untreated. In water absorption, 50/50 untreated had the highest absorption rate for 24 hours. The FTIR for untreated Luffa composite (50/50) revealed the fiber was hydrophilic due to the presence of OH group at 3100-3600 cm^{-1} wavelength band. The FTIR for treated Luffa composite (50/50) showed that the fiber was less hydrophilic with 2847.7 cm^{-1} for C=C and benzene ring conjugated diene at 2914.8cm^{-1}. On SEM, the Luffa composites (50/50) both for treated and untreated samples revealed the surface morphology and how strongly held the moulds were together.

Key words: *Luffa cylindrical*, polystyrene composite blend, sodium hydroxide solution.

INTRODUCTION

The idea of combining several components to produce a new material with new properties that are not attainable with individual components is not of recent origin. Humans have been creating composite materials to build stronger and lighter objects for thousands of years. Although composite materials had been known in various forms throughout the history of mankind, the history of modern composites probably began in 1937 when salesmen from the Owens Corning Fibreglass Company began to sell fibreglass to interested parties around the United States. Fiber glass had been made, almost by accident in 1930, when an engineer became intrigued by a fibre that was formed during the process of applying lettering to a glass milk bottle [1].

Composite materials are defined as materials consisting of two or more components with different properties and distinct boundaries between them. Wood is a natural composite of cellulose fibres in a matrix of lignin. The majority of composite materials use two constituents: a binder or matrix and reinforcement. The reinforcement is stronger and stiffer, forming a sort of backbone, while the matrix keeps the reinforcement in a set place. The binder also protects the reinforcement, which may be brittle, as in the case of the long glass fibres used in conjunction with plastics to make fibreglass. Thus composite materials are solid multiphase materials formed through the combination of materials with different structural, physical and chemical properties. Composites are widely used in such diverse applications as transportation, construction and consumer products [2]. In the mid 1960's, scientists and engineers began working on a new breed of aerospace materials called composites. A composite is an engineered material made from two or more ingredients with significantly differing properties, either physical or chemical. Generally, composite materials have excellent compressibility combined with good tensile strength, making them versatile in a wide range of situations. Composite materials take advantage of the different strengths and abilities of different materials. They offer unusual combinations of properties of component materials such as weight, strength, stiffness, permeability, biodegradability, electrical, and optical properties that is difficult to attain separately by individual components, with also nonconductive and nonmagnetic with optimum durability [3]. Composites have two significant advantages over some of the more traditional materials: greater strength and lighter weight. One of the most common forms of composite in use today is carbon fibre. It is made by heating lengths of rayon, pitch or other types of fibre to extremely high temperatures (~2000 ºC) in an oxygen-deprived oven. Metals alloys just like composites also have major improvements in strength, structure and durability. Nitinol is a composite of two metals, known as an alloy, that are chemically combined together, of Nickel and Titanium [4].

Not only Luffa that can produce such composites but can also be obtained from other plants, animals, and geological process. They can be used as component of composite materials. They can also be matted into sheets to make product like paper. Natural fibres are fibres derived from plants and animals.

a. Plants fibres include seed hairs which cotton are made of husk fibres that come from coconut, stem fibres such as flax and hemp, and leaves fibres which sisal is made from.

b. Animal Fibres; are made from hair and secretions produced from glands of caterpillars.

Artificial and Synthetic Fibres; which are polyester, polyolefin, acrylic nylon and rayon are made of scientists have the need to improved animal fibres and plant fibres, synthetic fibre are made of polymer materials which are coaling, plastic and rubbers. The synthetic fibre comes from petroleum base chemical or petroleum chemicals [5].

The fibre could be removed from the stem and not the leaf and then each stalk is cut into sheaths (boundless) into strips (narrow lengths) scraping strips to remove the pulp (a soft wet mass of fibre flesh) is either done by hand or machine as composites.

Luffa being able to produced natural fibres reinforced composites are emerging very rapidly as the potential substitute to the metal or ceramic based materials in applications that also include automotive, aerospace, marine, sporting goods and electronic industries. Natural fibre composites exhibit good specific properties, but there is high variability in their properties. Their weakness can and will be overcome with the development of more advanced processing of natural fibre and their composites. Their individual properties should be a solid base to generate new applications and opportunities for biocomposites or natural fibre composites in the 21st century "green" materials environment. Natural fibers are also used in composite materials, much like synthetic or glass fibers [6]. The exploitation of natural fibre composites in various applications has opened up new avenues for both academicians as well as industries to manufacture a sustainable module for future application of natural fibre composite. In the United States, composite building materials are being made from straw. Straw bales are being used in the construction of buildings. Many automotive components are already produced with natural composites, mainly based on polyester or polypropylene and fibres like flax, hemp, or sisal.

Plate 1: Pictures ofLuffa *(Luffa cylindrical*)
These are a number of Luffa Species which include

- *Luffa acutangula* (*Angled luffa, Ridged luffa, Vegetable gourd*)
- *Luffa aegyptiaca/ Luffa cylindrical* (*smooth luffa, Egyptian luffa*)
- *Luffa operculata* (wild loofa, sponge cucumber)

P**o**lystyrene is versatile plastic used to make a wide variety of consumer products. As a hard, solid plastic, it is often used in products that require clarity. Polystyrene is used to make appliances electronics, automobiles parts, toys gardening pots and equipment and more.

Luffa is a genus of tropical and sub- tropical vines in the cucumbia (*Cucurbitaceae*) family. The Luffa also spelled loofa, usually means the fruit of the two species *Luffae aegyptiaca and Luffa acutngula*. The fruit of this species is cultivated and eaten as a vegetable. The fully developed fruit is the source of the Luffa scrumbling sponge which is used in bathroom and kitchins. Luffa are not frst-hardy, and required 150 to 200warm days to mature.

Polystyrene are made into a form material called expanded polystyrene (EPS) or extruded polystyrene (XPS), which is valued for its insulating and cushiony properties. Polystyrene can be more than 95% air and is widely used to make home and appliance insulation, light height protective packaging, foodservice, and food packaging, automobile parts, roadway and stabilization systems. Polystyrene is a polymer obtained from the polymerization of styrene.

Some of these composites extracts have shown some level of toxicity on isolated organisms. A substantial phototoxic effect was seen with the three extracts against the *S. aureus* but not against the *E. coli* strain. Methanol extract of O. gratissimum (MEOG) and C. verbenaceae (MECV) were the extracts that showed the highest phototoxic activity [7]. After the treated and

untraeted luffa is blended with polypropylene, a nanocomposite is obtainedas Carbon nanotube metal matrix composites which is an emerging new material that is being developed to take advantage of the high tensile strength and electrical conductivity of carbon nanotube materials [8]. The use of untreated *Luffa* does not increase the mechanical properties of the bare resin. Nevertheless, its incorporation produces a change on the fracture mode of the composites from an abrupt one to a controlled and safer one [9].

The vegetal cell-fibers (CF) of *Luffa cylindrica* (LC) in relation to their microscopic morphology, the absorption after drainage and centrifugation, involved deionized water and saline solutions, was measured on both the raw fibers of the vegetal net and the cell-fibers previously extracted from ligneous fibrous strands (FS) with NaOH-anthraquinone alkali treatment [10]. In 2004, researchers worked on hemp and kenaf fibres were used in the as-received condition and alkalized with a 0.06 M NaOH solution to form hemp-polyester and kenaf-polyester composites [11]. Equally a research work was conducted on natural and man-made cellulose fibre reinforced plastics, introducing the possible applications of the material group. The physical properties of natural fibres were mainly determined by the chemical and physical composition, such as the structure of fibres, cellulose content, angle of fibrils, cross-section, and by the degree of polymerization [12].

MATERIALS AND METHODS

Set of sieve (China), Roll milling machine,XK630 (Italy), Grinding machine 13HP (China), Moulding machine, EN27 23000 (Denmark), Measuring cylinder 500 ml pyrex (China), Universal (digital) testing machine EnerPac P391 (New Nirma), FTIR machine Cary 630 FTIR Agilent technologies (USA), NaOH 3% solution, Polystyrene.

Sample Collection

Luffa was obtained from Anka, Anka local government, Zamfara. The Luffa bark was peeled, cut, seeds removed, washed with water and sun dried.

Treatment of Luffa fiber

The Luffa was treated with 3% NaOH, then allowed for 3 hours, washed with distilled water until pH 7 was obtained, then dried in oven for 72 hours and crushed.

An untreated Luffa was washed with distilled water and dried for 72 hours and crushed.

Production of the composite for the Research

Five composites were produced in the following ratios as designed [13]:

a. composite 1: 10 g of Luffa with 90 g of polystyrene
b. composite 2: 20 g of Luffa with 80 g of polystyrene
c. composite 3: 30 g of Luffa with 70 g of polystyrene
d. composite 4: 40 g of Luffa with 60 g of polystyrene
e. composite 5: 50 g of Luffa with 50 g of polystyrene

The crushed untreated Luffa was made into one composite: 50 g of Luffa with 50 g of polystyrene. Each sample was compounded for the formation of the composite with the polymer introduced into two roll milling machine at 150 ºC. Until the polymer melted, the Luffa was introduced into the two roll milling machine. This was done until a homogenous mixture was obtained after about 15-20 min. The mixture was introduced into 12 by 12 cm plate before compounding, and cooled by the cooling machine to maintain the shape of the polymer.

Characterization of the Molds

Infra-red Spectroscopy

The IR test was performed on 50-50 g of both treated and untreated mold.

Mechanical Test

Flexural Test: Flexural strength test was carried out on the five treated samples and one untreated sample usin a mosana Tensometre. Samples were prepared to dimension 206010 mm. The composite were subjected to building by supporting them at end and mid points load applied until failure as recommended in ASTM D790 [14]. Calculated using the formula below:

$F= (3pl/2bd^2)$ MPa

Where p =is the maximum deflection force (N)

b= is the width of specimen (mm)

d= is the thickness (mm)

L is the Gauge length of specimen (mm).

Scanning Electron Microscopy

Examination of the samples were carried on 50-50 treated and untreated to reveal the surface morphology and to establish whether the synthesised composite, crushed treated and untreated luffa, produced are strongly held together.

Water Absorption Test

A portion of the synthesised composite was sectioned, weighed (initial weight) W_1 and immersed in the distilled water for 12 hrs, 24 hrs and 48 hrs. Then the samples were removed from the distilled water, cleaned with blotting paper and dried, then weighed again (final weight) w_2 and recorded [15].

RESULTS AND DISCUSSION

FTIR

This FTIR spectra of the treated and untreated luffa reinforced composites are presented in figure 1 and 2

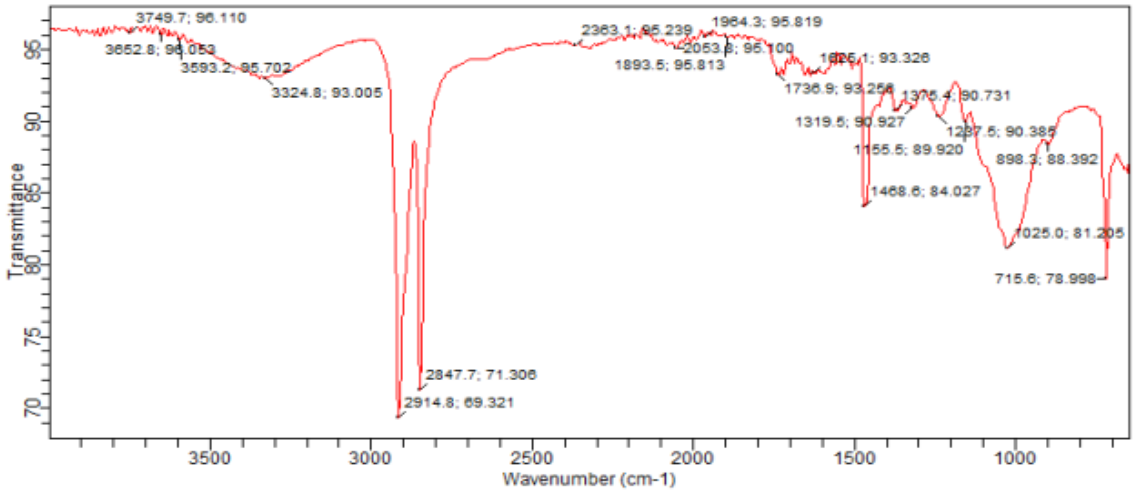

Fig.1: FTIR Spectrum for Untreated luffa composite (50/50)

The IR of the untreated luffa revealed that OH group are present in the luffa fiber which makes it hydrophilic in figure 2. The band 3100-3600 is for the OH group. This means that the cellulose fiber has higher tendency to take water and any band between 2800-2950 represent C-H bond.

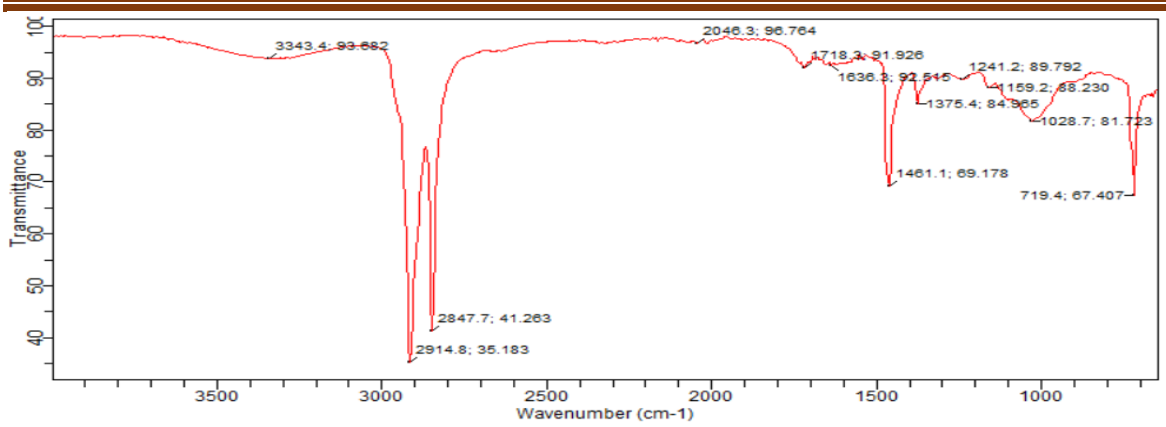

Fig.2: FTIR Spectrum for Treated luffa composite (50/50)

The IR spectrum of the treated luffa composite showed thin broad line around 2914.8cm^{-1} depicting the presence of a benzene ring and the range reading 2847.7cm^{-1} was the presence of C=C- from polystyrene that made the composites hydrophobic.

Result for Flexural Test of the Composites

The flexural strength is the ability of a composite to withstand bending. In this research the effect of treatment of fiber and also the effect of concentration of fiber or matrix were studied.

Table 1: Flexural Strength of the composite (Nmm^2)

Sample	Strength
90/10	2.21
80/20	4.25
70/30	2.32
60/40	3.95
50/50 Treated	1.37
50/50 Untreated	3.71

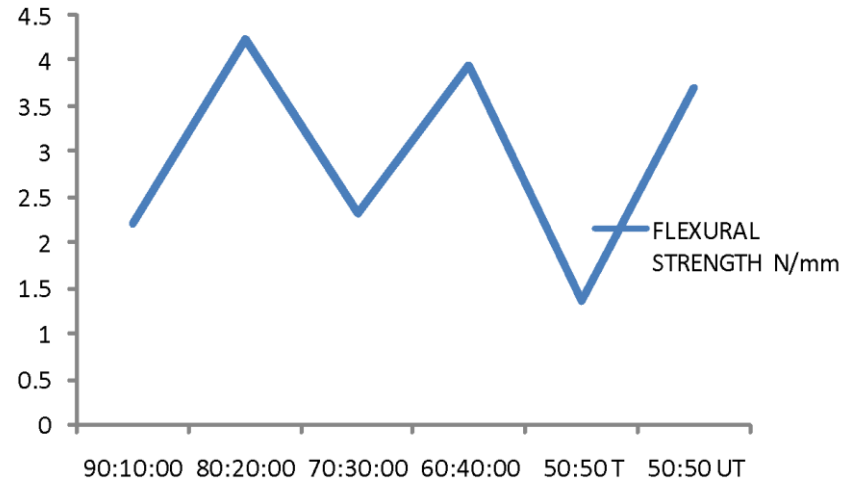

Fig.3: Line Graph Representation of Flexural Strength Composites

The Flexural test measured the force required to bend a beam under three-point loading condition. The data are often used to select materials for parts that will support loads without flexing. Flexural modulus is used as an indication of a material stiffness when flexed. Since the physical properties of many materials (especially thermoplastic) can vary depending on ambient temperature, it is sometimes appropriate to test materials at temperatures that stimulate the intended end used in the environment.

Table 1 shows the results of flexural strength test of treated and untreated composite, 80 g polystyrene and 20 g luffa which have higher strength of 4.25 than 60 g of polystyrene and 40 g luffa of 3.95 and 50 g of polystyrene and 50 g luffa untreated composite have higher strength of 3.71 than 50 g polystyrene and 50 g luffa with 1.37 in the flexural mechanical test. This shows that 80 g polystyrene and 20 g luffa have higher strength, and 90 g polystyrene and 10g luffa have lower strength of 2.21.

Results of Scanning Electron Microscope Test

The SEM micrographs for the treated and untreated composites are shown in plates 1 and 2.

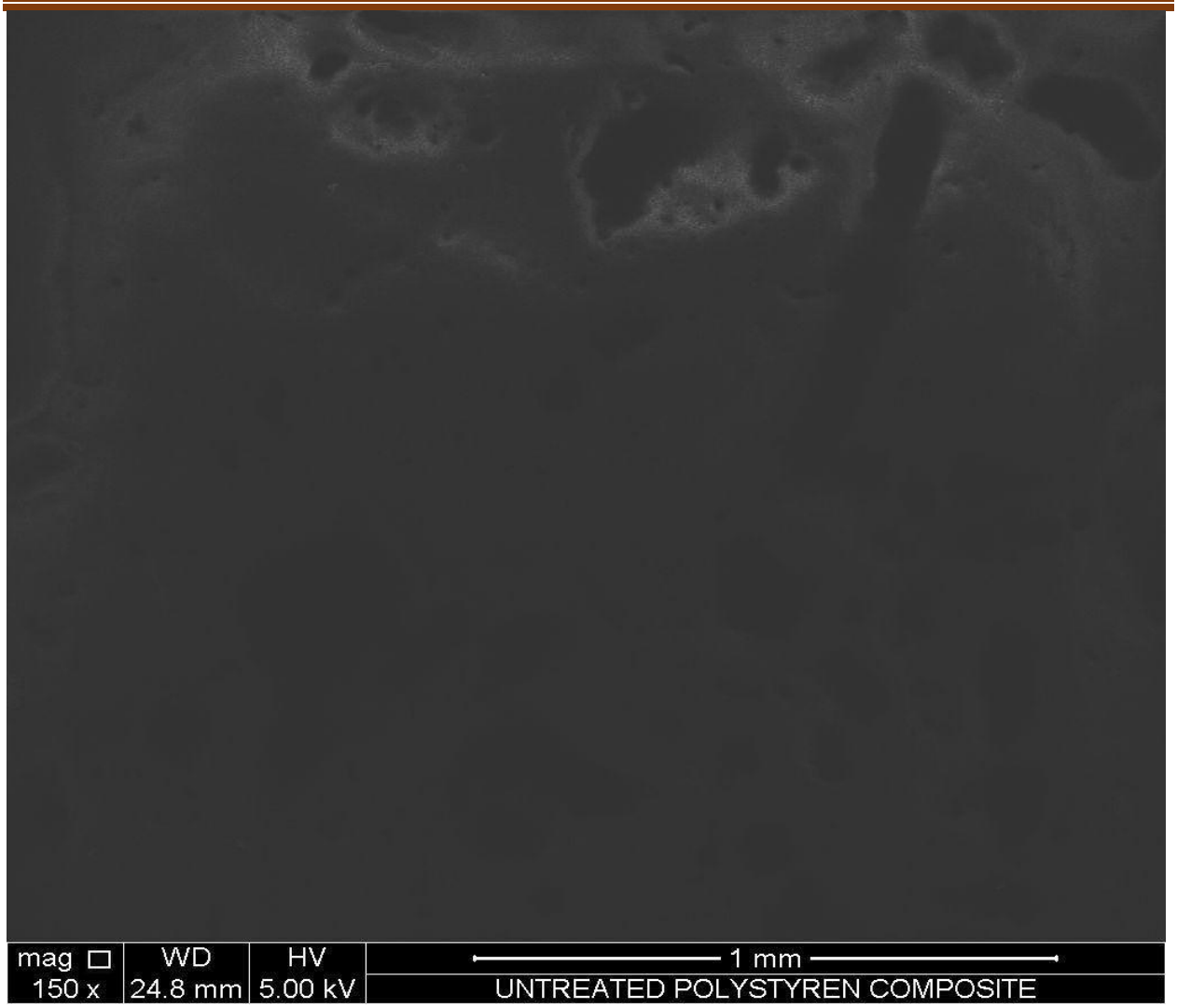

Plate 1: SEM Micrograph for Untreated Luffa Composite (50/50)

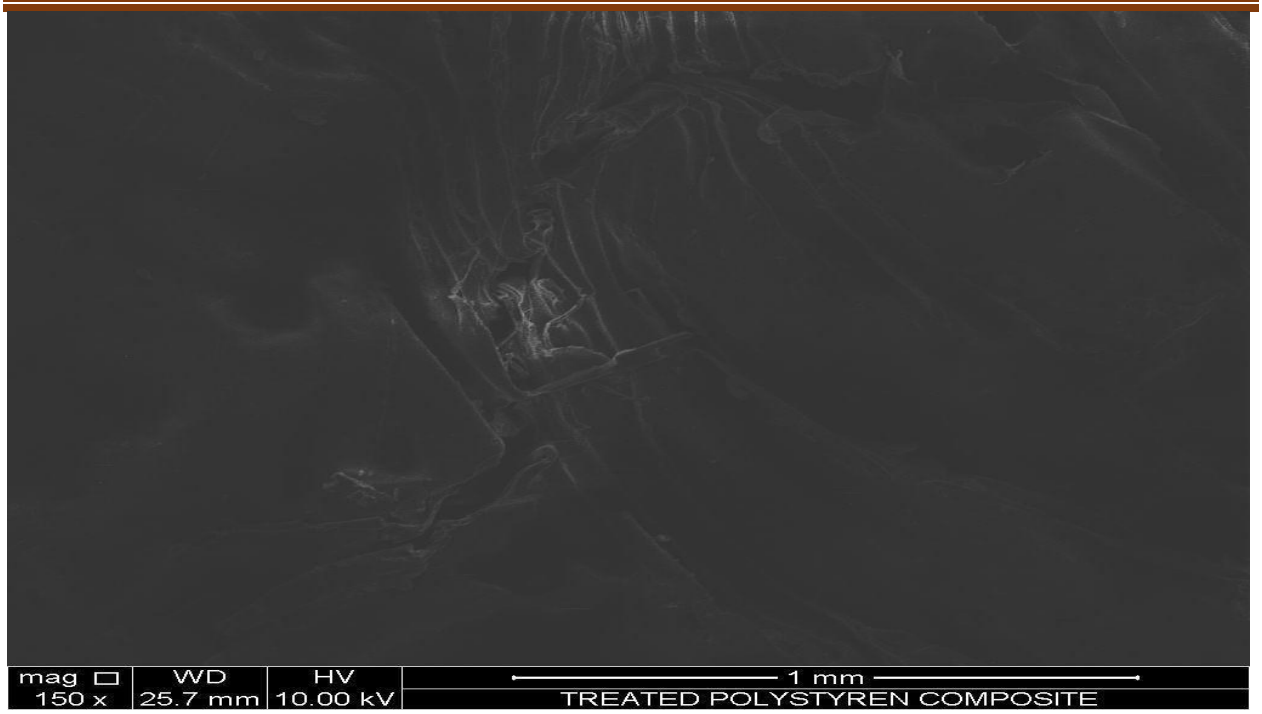

Plate 2: SEM micrograph for Treated luffa composite (50/50).

Examination of the samples wase carried on 50-50 treated and untreated that revealed the surface morphology and established whether the synthesized composite, crushed treated and untreated luffa produced, were strongly held together. In the SEM micrograph of the fracture surface of fiber reinforced polymer composite, the surface appeared a bit rough because of the absent of lignocelluloses component of the fiber on the composite due to the treatment which differentiate the micrograph of treated and untreated composites.

Water Absorption capacity of the Composite

Table 2: The Water Absorption test Results for both treated and untreated samples

Sample	Initial $_{(w1)}$	Final $_{(w2)}$	% of H_20	12 hours
60/40	1.9	2.0	5.26	12
	2.3	2.4	4.35	24
	2.1	2.2	4.76	48
50/50 UT	2.6	2.7	3.85	12

	2.2	2.4	9.09	24
	3.0	3.2	6.67	48
50/50 T	1.4	1.5	7.14	12
	3.1	3.2	3.23	24
	2.2	2.3	4.55	48

The water absorption result which gave information about the extent of water absorption of material was carried out on three composites, 60 g polystyrene and 40 g luffa, 50 g polystyrene 50 luffa treated and 50 g polystyrene 50g luffa untreated each for 12, 24, and 48 hours which gave the percentage absorptions for both initial and final. It implied that composite for 12 hours 50/50 treated absorbed more water while the 24 hours 50/50 untreated absorbed more water than 50/50 treated and for 48 hours, no absorption of water in both treated and untreated.

CONCLUSION

This research resulted in the successful production of composite from mixing of natural fibre and polymer. The reinforced natural fiber possessed some beneficial properties like low density, fewer expenses and reduced solidity giving an advantage for utilization in commercial purposes. These reinforced fibers were evaluated for their properties, namely, mechanical, moisture absorption and flame retardation. The study confirmed that the developed composite is biodegradable and eco-friendly.

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