International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 761-773 www.ijaem.net ISSN: 2395-5252

Coconut-Glass Fibre Reinforce Polymer Composite for Automobile Bumper Structural Component; Comparative Analysis

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Submitted: 01-08-2021 Revised: 10-08-2021 Accepted: 15-08-2021

ABSTRACT: Material developers are constantly faced with the challenges of creating materials with good mechanical properties and of low density, thus the need for continuous research in composite material development. Natural fiber composite offers significant opportunities for renewable, biodegradable and recyclable materials and from sustainable sources at the same time. Natural fibre composites have low costs, tool wearing rates, production energy requirements and low health and safety risks, as well as good formability, acoustic and thermal insulation properties. Despite these advantages, restrictions such as hydrophilic properties, low-impact strength, non-uniformity and low processing temperature are undesirable mechanical properties that limit their application to non-structural and semi-structural automotive components. Physic-chemical properties that directly affect developed composite such as variation of Density, Water Absorption, Tensile Strength, Bending strength, Modulus of rupture, Impact Strength and Hardness Values were investigated for both unhybridized and hybridized developed composite. Hybridized samples (CF-GF/RLDPE) showed higher strength when compared to un-hybridized (CF/RLDPE) composites. The microstructure studies showed good interfacial bonding between reinforcement and matrix leading to good mechanical properties for the hybridized composites. Furthermore, a comparative analysis was carried out between the properties of the hybridized and un-hybridized composite samples and the control sample (Toyota Camry 2009 model). Based on the results obtained in this study, these grades of composites can be used in the production of low strength car bumper.

KEYWORDS: Coconut fiber; Continous glass fiber straw; Car bumper; Hybridized; Polymer.

I. INTRODUCTION

Steel has been the material of choice for automobile structures since Henry Ford's introduction of mass production in 1913 [1]. Notably, most of the plastic applications in vehicles are lower-performance commodity polymers and short-fibre composites. The use of advanced composites in structural vehicle body applications has been far less extensive, but there have been some notable recent applications [2]. Polymer composite materials are used in a wide range of structural applications in the aerospace, construction and automotive industries due to their lightweight and high specific stiffness and strength [3]. A variety of materials are being used ranging from lower performance glass fibre/polyester, used in small sail boats and domestic products, to high performance carbon fibre epoxy systems used in military aircraft and spacecraft. One sector where the use of composite materials is still evolving is the automotive industry. Composite materials offer great potential in reducing vehicle weight, thus increasing fuel efficiency and reducing carbon dioxide (CO_2) emissions. In addition to weight reduction, the number of individual parts can be significantly reduced making the high-volume composite car concept cost effective [3, 4].

Fibre reinforced composite materials have been widely used in various transportation vehicle structures because of their high specific strength, modulus and high damping capability. If composite materials are applied to vehicles, it is expected that not only the weight of the vehicle is decreased but also that noise and vibration are reduced [5].

Most composites currently used by industry are designed with long-term durability in mind. Generally, bio-fibre can be used as both fillers and reinforcement for automotive interior components. Current applications, with typical

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Volume 3, Issue 8 Aug 2021, pp: 761-773 www.ijaem.net ISSN: 2395-5252

weights of used natural fibres are presented in Table 1. Bio-fibre reinforcement in blended thermoplastic or resinated thermoset compression moldings is now generally accepted for applications as door liners/panels, parcel shelves and boot liners. The manufacturers and models are known to incorporate natural fibres for such components to a greater or lesser extent. Table 2 presents typical weight of natural fibre used in various automotive structure.

Table 1. Typical weight of natural fibres used in automotive component

Automotive component	Typical weight of Fibres(kg)
Front door liners	1.2-1.8
Rear door liners	0.8-1.5
Boot liners	1.5-2.5
Parcel shelves up to	2.0
Seat backs	1.6-2.0
Sunroof sliders up to	0.4
NVH material min	0.5
Headliners average	2.5

Source: [6]

Table 2. Automotive manufacturers, models and components using bio-fibres

Automotive Manufacturer	Model and Application
Audi	A2,A3,A4 Avant,A6,A8,Roadstar,Coupe seatback, side and backdoor panel, boot lining, hat rack, spare tire lining
BMW	3.5 and 7 series and others: Door panels, headliner panel, boot lining, seat back
Daimier Chrysler	A, C, E, S class: Door panels, windshield/dashboard, business table, piller cover panel. A class, Travego bus: exterior under body protection trim M class: Instrument panel (Now in S class: 27 parts manufactured from bio fibres, weight 43kg)
Fiat	Mondeo CD 162, Focus: Door panels, B-piller, boot liner
Opel	Astra, Vectra, Zafira: Headliner panel, door panels, pillar cover panel, instrument panel
Peugeot	New model 406
Renault	Clio
Rover	Rover 2000 and others: insulation, rear storage shelf/panel
Saab	Door panels
SEAT	Door panels, seat back
Volkswagen	Golf A4, Passat Variant, Bora: Door panel, seat back, boot lid finish panel, boot liner
Volvo	C70, V70
Mitsubishi	Space Star: Door panels Colts: Instrument panels

Source: [6]

Various studies have been conducted in implementing composites materials for automotive bumper beam design. [2]. developed a one piece, injection mould thermoplastic rear bumper system with pole impact protection. [6]. described their extensive work on bumper beams using continuous glass fibre composites to study the stress contour in for a passenger car. The material used was glass

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fibre epoxy composite material, except for the elbow section. [7]. developed an I-section beam with 40% chopped glass fibre GMT (glass mat thermoplastic). They found that an I-section bumper design has improved the static load and the dynamic impact performance of mineral filled/chopped glass fibre GMT, in the development.

[8]. evaluated the performance of polyolefin in comparison with engineering thermoplastics for blow moulded bumper beams for mid-size vehicles. Since many researchers are devoted to designing a polymeric based composite bumper beam to reduce weight, The bumper system is a structural component, which contributes to the crashworthiness or occupant's protection during a front or rear collision. There is an interest among the researchers to move from conventional materials such as plastic, aluminum, or steel to materials such as polymeric based composites in the bumper system. The development of bumper system using sheet moulding compound (SMC) for automobile was reported in the literature [4].

The composite material used was random chopped glass fibre. Mechanical properties of the material, such as tensile strength, tensile modulus and hardness were tested for acceptable performance of the material. [6]. described their extensive work on bumper beam using glass fibre-reinforced plastics to study the stress contour in the component. [9]. selected polymeric based composite materials because of low weight, high specific stiffness, high specific strength, high-energy absorption and easy to produce in complex shapes to produce bumper fascia for Proton Iswara1.3sAeroback. The bumper fascia was made of conventional polyurethane (88 % by weight) and PRIMGLOS (8% by weight)/K46glasssphere (4 % by weight) materials. In this design, the fascia consists of many curvatures and it is a one-piece moulded part that is used to manufacture by SMC. In order to strengthen the bumper fascia, the energy absorber (foam) made of polyurethane was attached on the backside of the fascia. The rib was designed to support the removable portion of bumper. The rib has a 3 mm thickness, 40 mm width and it follows the shape of the removed portion on the fascia. Four conceptual designs of a bumper fascia have been developed with a 3-D solid model that had been carried out using Pro/Engineer software, the weight of the bumper fascia was obtained through weight analysis of software as well. To decide the final design of bumper fascia, the matrix evaluation method was used. The evaluation of the bumper fascia conceptual designs was carried out using the weighted objective method. For each concept, the utility score for each objective was multiplied with the weight to give relative values. These values were summed up to get the total values of each concept. The concept with the highest values was selected. Some parameters are not measurable in simple, quantified ways, but it is possible to assign utility scores estimated on a points scale. Finally, the relative utility value of the concepts are calculated and compared. By multiplying each parameters core by its weighted value, the 'best' alternative that has the highest sum value is chosen as the 'best'. The fascia was successfully designed with less weight compared to the current fascia. [10]. applied a conceptual design approach to the development of polymeric-based composite automotive bumper system. Various methods of creativity, such as mind mapping, product design specifications, brainstorming, morphology chart, analogy and weighted objective methods employed for the development of composite bumper fascia and for the selection of materials for bumper system. The evaluation of conceptual design for bumper fascia is carried out using weighted objective method and highest utility value is appeared to be the best design concept. Polymer-based composites are the best materials for bumper fascia, which are aesthetically pleasant, lighter weight and offer many more advantages that are substantial. [11]. This study is focused on hybridization of natural fibers (coconut fibers) with glass fiber to enhance the desired mechanical properties for the application of natural fibers to automotive structural components such as a car passenger bumper beam.

II. METHODOLOGY

The materials used in this work are reinforced low density polyethylene (RLDPE) as binder while natural Coconut fibres (CF) and continuous Glass fibre (GF) strands of ASTM D578/ D578M – 18 standard was used as reinforcements. Figure 1 (a) and (b) shows the extracted coconut fibre before further processing and Low density polyethylene after washing thoroughly before shredding.

International Journal of Advances in Engineering and Management (IJAEM)
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(a) (b)

Fig.1(a) Coconut fibre and (b) Low density polyethylene sachet water bags

Waste low density polyethylene sachet water bags were collected literally from the streets of Minna, Nigeria and were washed, dried and cut in to small pieces with the aid of a film shredder. Glass fibre was purchased from an engineering store and was identified by a metallurgist from the federal university of technology Minna, Niger state, Nigeria.

Extraction of the Coconut Coir

The coconut fibres were obtained from a farm settlement centre along Ilorin-Ibadan expressway in Ogbomosho, Oyo State Nigeria. The procedure for the coconut coir extraction was in accordance to ASTM D578 / D578M**.** The mature coconut coir obtained from the farm was cut to a length of 30 cm each and sliced longitudinally into four pieces and totally submerged in water for 15 days, after which the coir was removed from the water and loosened by lapping back and forth in a pool of tap water. They were subsequently sun dried for eight hours and further loosened by manual combing. The extracted fibres was then treated with 5 % sodium hydroxide (NaOH) solution for four (4) hours under total immersion condition to avoid oxidation of the fibres, and then washed in overflowing tap water until neutral pH was attained. The treated fibres were dried in an oven for 24 hours at 105 ^{o}C to remove free water and subsequently stored separately in an air tight container. The treated fibres were then used for the study.

Sample Preparation

Metal Molds were used in the production of the coconut composite samples. Each mold had a cavity that accommodated the composite samples. The dimensions and shapes of cavities were made according to the size and shape of the samples using ASTM Standard D 638-90 for tensile testing and ASTM Standard D 790-97 for flexural testing (ASTM, 1990). The fibres (random oriented) and the binder were mixed by compounding into a homogenous mixture using two roll mills at 130 ^{0}C. The compounded mixture was compressed at 150 ^{o}C and a pressure of 10 MPa for 15 minutes to form the bumper composites. Composites were developed with 5, 10, 15, 20, 25 and 30 % (by weight) of fibres. The coconut fibre (CF), glass fibre (GF) and the RLDPE were formulated according to Tables 3-4.

Table 3: Formulation of the composites using CF/RLDPE

S/n	Coconut fibres (%wt)	RLDPE(%wt)
1.	0	100
2.	5	95
3.	10	90
4.	15	85
5.	20	80
6	25	75
7	30	70

Table 4: Formulation of the hybrid composite using CF-GF/RLDPE

S/n	Coconut fibre (%wt)	Glass fibre	RLDPE(%wt)
1.	0	0	100
2.	2.5	2.5	95
3.	5.0	5.0	90
4.	7.5	7.5	85
5.	10	10	80

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6	12.5	12.5	75
7	15	15	70

Chemical and Morphological Analysis

The elemental composition of the coconut fibres was determined using X-ray fluorescence (XRF) analysis in the Multi-User Science Research laboratory. The scanning electron microscope (SEM) JEOLJSM-6480LV was used to identify the surface morphology of the composite samples. Samples were washed, cleaned thoroughly, air-dried and coated with 100Åthickplatinumin JEOL sputter ion coater and SEM observed at20 kV. Samples were sputter-coated with gold to increase surface conductivity.

Physio-chemical Characteristics

Test samples were cut from the composites for the mechanical and physical tests according to the recommended Standard for each test. The following tests were carried out:

Density Determination

A clean sample was weighed accurately in air using a laboratory balance and then suspended in water. The weight of the sample when suspended in water was determined, the volume of the sample was determined from the effect of displacement by water (Archimedean principle).

The density of the sample was estimated from equation below:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad (1)$$

Water Absorption (WA) Test

This was carried out in order to determine the water absorption of the composite as a result of direct contact and exposure to free water**.** Specimens with dimensions of 50 mm x 50 mm were prepared for evaluation of the water absorption. The test specimens were placed in water in parallel for 30 min and soaked for 24 hours before further measurement of the weight of the soaked samples. The values of the water absorption as percentages were calculated.

$$WA = \frac{Wt - Wo}{Wo} \times 100\% \quad (2)$$

Where: WA (t) is the water absorption (%) at time t,

Wo is the initial weight, and

Wt is the weight of the sample at a given immersion time t.

Tensile Test

Tensile strength indicates the ability of a composite material to withstand forces that pull it apart as well as the capability of the material to stretch prior to failure. The ASTM standard test method for tensile properties of polymer composites with the designation D3039-76 was used and to measure the instantaneous applied load and the resulting elongations simultaneously using an extensometer.

The Tensile strength is calculated from the formula below (ASTM, 1990):

$$\sigma = P/bh \quad (3)$$

Where:

σ = Tensile Strength

P = axial load

b = guage width and

h = guage thickness

Static Bending Test

The breaking point of the composite sample and its elongation was determined by this test. A static bending test (dry) was conducted using the universal materials testing machine on specimen size 150 mm x 50 mm x 4 mm according to American Society for Testing and Materials standard D1037. A concentrated bending load was applied at the centre with a length 15 times the thickness of the specimen. The bending modulus of rupture (MOR) was calculated according to the following formula:

$$MOR = \frac{3P_bL}{2bh^2} \quad (4)$$

Where: P_b is the maximum load (N); b is the width of the specimen (mm); h is the thickness of the specimen (mm) and L is the span (mm).

Impact Strength

The impact test of the composite samples was conducted using a fully instrumented Avery Denison test machine, model number "$C_{at}.N_r.412$" of capacity 15 – 25J. A Charpy impact test was conducted on notched samples. Standard square impact test samples measuring 80 x 10 x 10 mm with notch depth of 2 mm and a notch tip radius of 0. 02 mm at angle of 45^o were used (ASTM, 1990).

Hardness Test

The hardness of a composite is the relative ability of the material surface to resist indentation by an indenter of specified dimension under a specified load. Hardness test of the bumper samples was done to determine the materials ability to resist plastic deformation**.** Enerpac Universal Materials Testing machine (BS903 part A 26)(ASTM, 1990) was used using 1.56 mm steel ball indenter, minor load of 10 kg, major load of 100 kg.

III. RESULTS AND DISCUSSION

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Density of the Developed Composites

The results reveal from (Figure 1) that compoiste slightly increased the density of the coconut fibre reinforced polymer composites. The density of the fibre reinforced polymer composites (FRPCs) decreased from 0.96 g/cm^3 at 0 Wt. % of coconut fibre addition to 0.72 g/cm^3 at 30 Wt. % for un-hybridized bumper samples, and 0.99 g/cm^3 at 0 Wt. % to 0.76 g/cm^3 at 30 Wt. % for the hybridized bumper samples. Hence, not much change in the PMCs density was observed. This is in line with the earlier works carried out by [9,12,13]. However the density obtained are within the recommended standard for the low speed impact bumper.

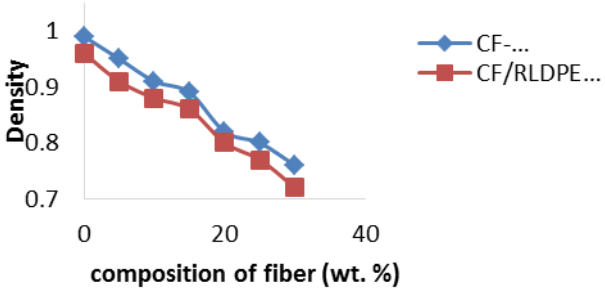

Figure 1: Variation of density versus percentage composition of fibre

Water Absorption of the Developed Composites

Hybridization decreases the water absorption of the natural fibre reinforced composites see Figure 2. The low level of water absorption recorded may be due to the addition of glass fibres to the natural fibres, and the surface treatment of the natural fibres with alkali (NaOH) solution. Similar observation was reported by [14] for other natural fibres. This increased interfacial bonding between the RLDPE and the fibres, thus leading to decrease in the porosity level, hence the solubility values of the composites. The swelling that occurs during the water absorption may be due to the release of compression stresses imparted to the composites during the pressing of material in the hot press. The release of compression stresses known as spring back is not recovered when the composites are in a dry state. The results obtained for CF-GF/RLDPE composites are within the recommended standard for a car bumper.

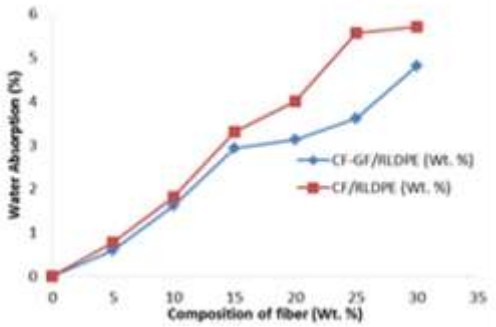

Figure 2: Variation of water absorption versus percentage composition of fibre

Tensile Strength of the developed composites

The tensile strength of the natural fibre reinforced polymer composites decreases as the composition of fibre in the matrix increases and vice-versa.The tensile strength decreased from 20.0 MPa at 0 Wt. % fibre addition to a minimum of 2.9 MPa at 30 Wt. % for both the hybridized and the un-hybridized natural fibre reinforced composites. However, within this range, hybridization increases the tensile strength of the CF/RLDPE composites slightly (Figure 3). The tensile strength and moduli of the CF-GF/RLDPE composites showed higher values than CF/RLDPE composites because of hybridization of the coconut fibre with glass fibre. This accounts for the good distribution and dispersion of the fibres in the RLDPE matrix resulting in strong fibre-RLDPE interaction. Nevertheless, the tensile

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 761-773 www.ijaem.net ISSN: 2395-5252

strength obtained in this study remained within acceptable levels for car bumper [9,12,15].

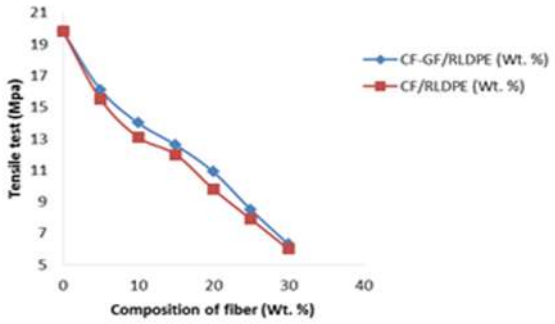

Figure 3: Variation of Tensile strength versus percentage composition of fibre

Bending Strength of the Developed Composites

The bending strengths of the hybridized and the un-hybridized composites were obtained experimentally from the bend tests as revealed in Figure 4. It is interesting to note that bending strength increased with increase in the reinforcement fibre content in the RLDPE matrix. For example bending strength of 13.0 MPa was recorded for CF/RLDPE (un-hybridized) composite and 14.70 MPa for CF-GF/RLDPE (hybridized) composite at 10 Wt. % fibre composition. There is an improvement in bending strength of the composite as particle weight fraction increases. The random planer arrangement of the fibres is likely to lead to rigidity and better absorption of compressive forces, leading to increase in overall bending strength. This observation is in line with the researches of [13].

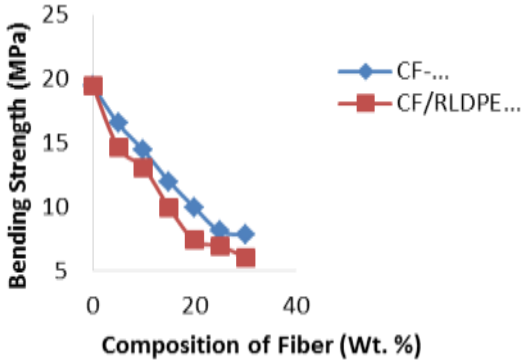

Figure 4: Variation of Modulus of rupture versus percentage composition of fibre

Impact Strength of the Developed Composites

The results of the impact strength shows that the impact strength of the coconut fibre reinforced low density polyethylene composites slightly increased with increase in glass fibre addition (Figure 5). High strain rates or impact loads may be expected in many engineering applications of polymer composite materials. The suitability of a polymer composite for such applications should therefore be determined not only by usual design parameters, but by its impact or energy absorption. The steep increase in the impact strength composites could be attributed to hybridization and the presence of fibres well bonding by the RLDPE which leads to increase in impact strength. The steep improvement in the impact energy of the composites could be attributed to good interfacial bonding between the matrix and the fibres which was achieved by surface treatment of the fibres with alkali (NaOH) solution. These results are in agreement with the work of other researchers [9,12,15].

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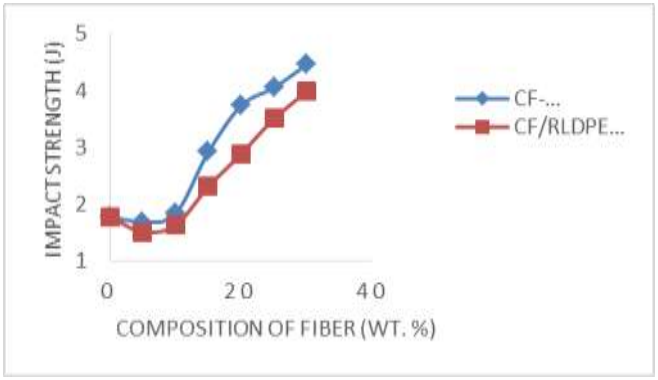


Figure 5: Variation of Impact strength versus percentage composition of fibre

Hardness Values of the Developed Composites

The results obtained show that the hardness values of the composite samples increases as the percentage of fibre addition increases in the RLDPE matrix (Figure 6). This is due to increase in the percentage of the hard and brittle phase of the ceramics body in the polymer matrix. In comparison with the unreinforced RLDPE matrix, a substantial improvement in hardness values was obtained in the reinforced polymer matrix. This is in line with the earlier researches of [9,12]. In Figure 6, hybridization increases the hardness of the natural fibre reinforced composites.

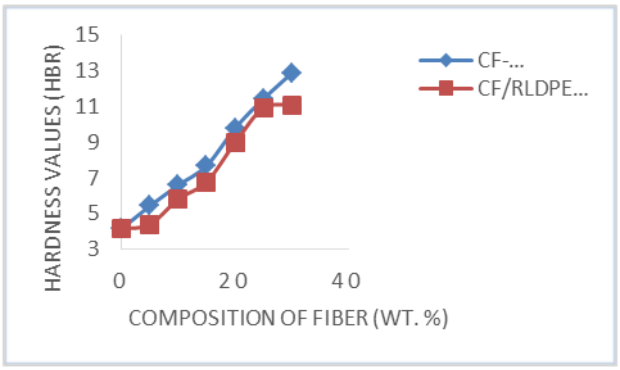


Figure 6: Variation of Hardness values versus percentage composition of fibre

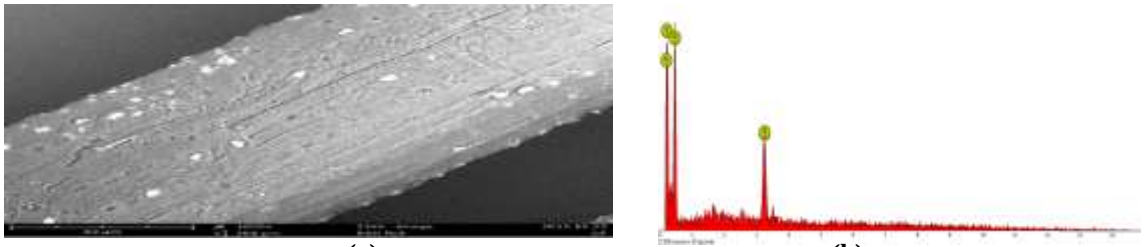
Microstructural Properties (SEM) Analysis

The microstructures of the coconut fibre (Plate I) by Scanning Electron Microscope (SEM) revealed that the coconut fibres are solid in nature but irregular in size. The microstructure of the RLDPE matrix of (Plate II) reveals a chain of lamellae and interlameller amorphous structure with linear boundaries between adjacent spherulites boundaries. Microstructural analysis using SEM clearly shows difference in the microstructures of the RLDPE and its composites. Microstructural studies of the hybridized and the un-hybridized fibre reinforced composites revealed a uniform distribution of the reinforcement fibres with the RLDPE binder. The distribution of the fibres is influenced by the compounding of the fibres and the binder which resulted to good interfacial bonding as shown in the developed bumper samples. The morphologies of the car bumper composites by SEM are shown in Plates I-XVII. The microstructure clearly shows that when the fibres was added to the RLDPE binder, morphological change in the structure take place.

The microstructure reveals that there are small discontinuities and a reasonably uniform distribution of the reinforcement fibres and the RLDPE binder. The reinforcement fibres phase is shown as white phase, while the binder phase is dark. Similar observation was reported by [16]. The fibres are embedded within the amorphous matrix composed of randomly distributed matrix planar boundaries. The surface of the fibres is smooth indicating that the compatibility between fibres and the binder was good. It can be seen that the reinforcement fibres are not detached from the RLDPE surface as the weight fraction of the fibres increased in the binder; this is due to good interfacial bonding between the binder and the fibres (BSI, 1993). This good bonding was

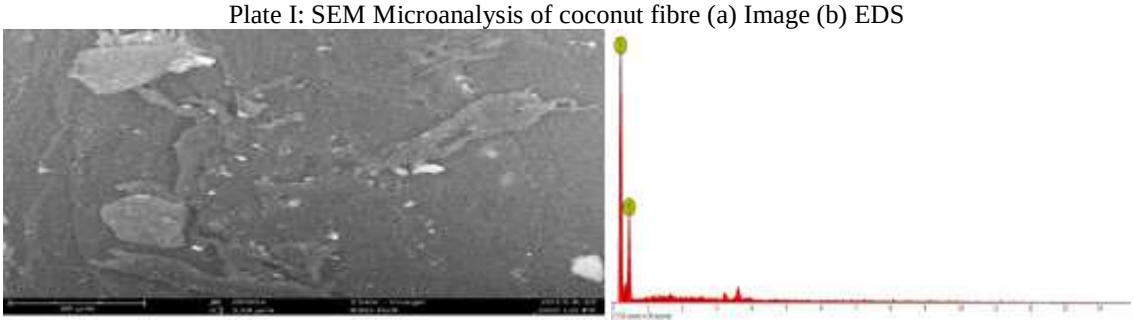
International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 761-773 www.ijaem.net ISSN: 2395-5252

achieved from the compounding of the fibres and the RLDPE binder.



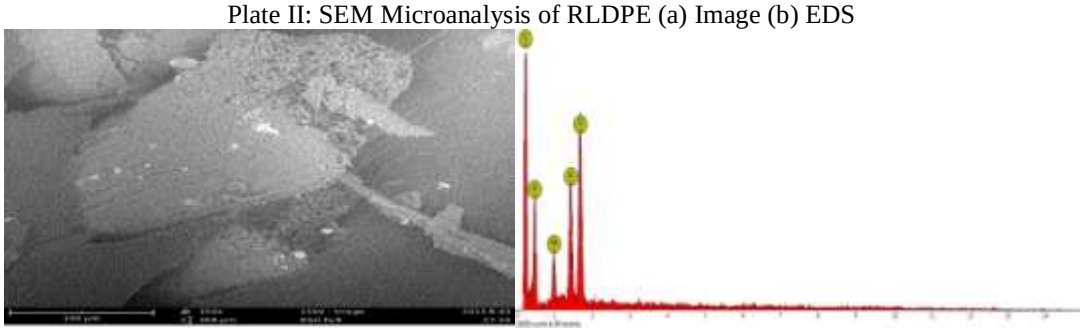
(a) **(b)**

Plate I: SEM Microanalysis of coconut fibre (a) Image (b) EDS



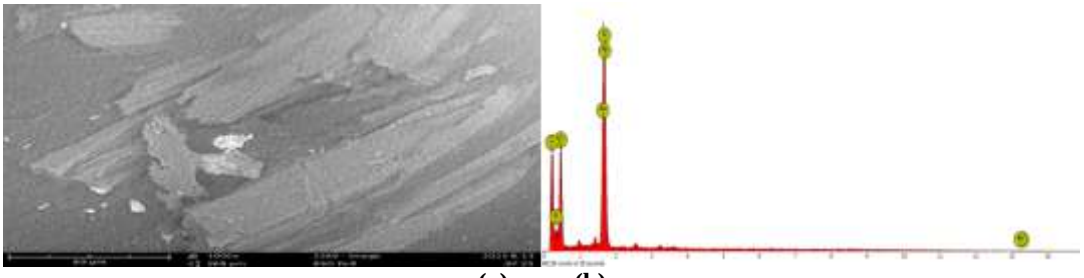
(a) **(b)**

Plate II: SEM Microanalysis of RLDPE (a) Image (b) EDS



(a) **(b)**

Plate III: SEM Microanalysis of 25% wt. CF-GF/RHDPE hybrid composite (a) Image (b) EDS



(a) **(b)**

Plate IV: SEM Microanalysis of 30% wt. CF/RLDPE composite (a) Image (b) EDS

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 761-773 www.ijaem.net ISSN: 2395-5252

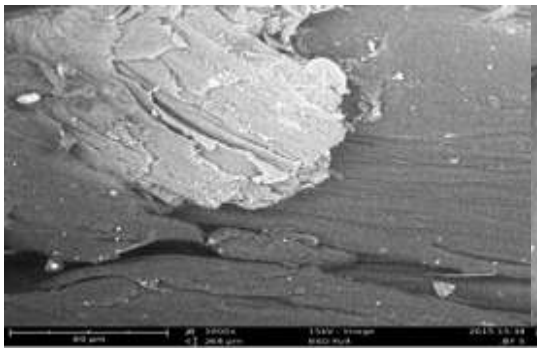


Plate V: SEM Microstructure of 5% wt. CF composite

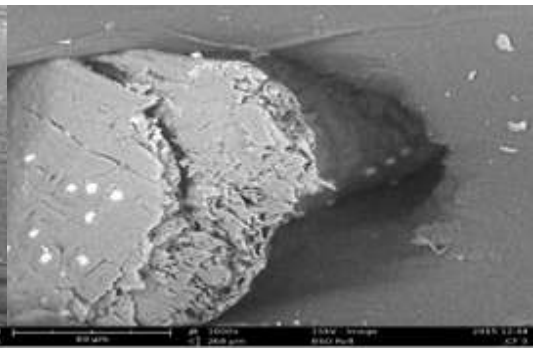


Plate VI: SEM Microstructure of 5% wt. CF-GF hybrid composite

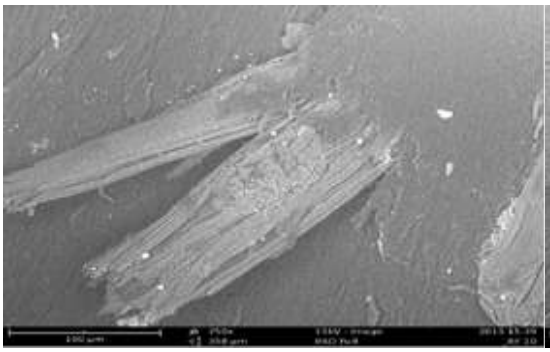


Plate VII: SEM Microstructure of 10% wt. CF composite

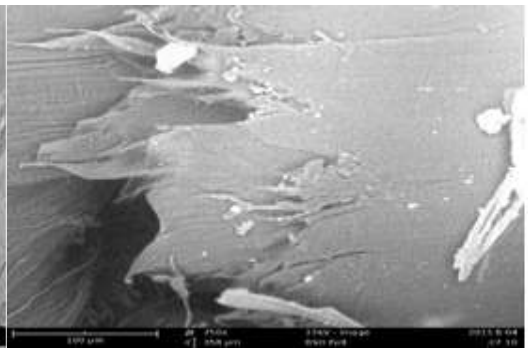


Plate VIII: SEM Microstructure of 10% wt. CF-GF hybrid composite

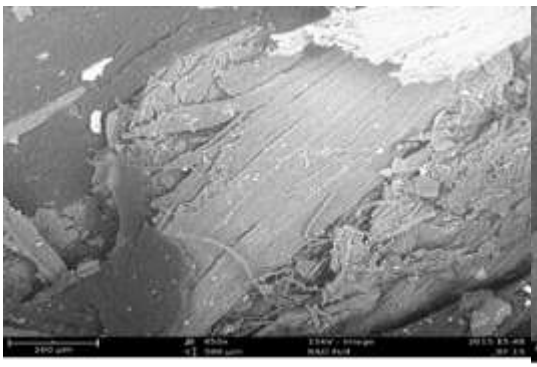


Plate VIV: SEM Microstructure of 15% wt. CF composite

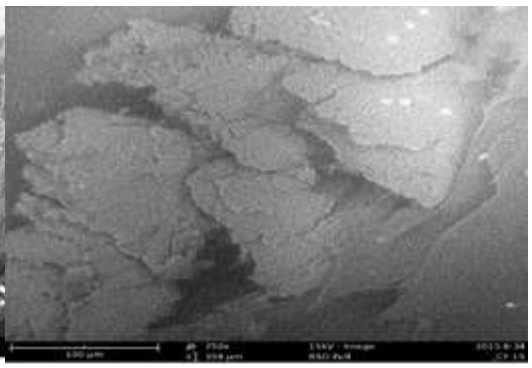


Plate XV: SEM Microstructure of 15% wt. CF-GF hybrid composite

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 761-773 www.ijaem.net ISSN: 2395-5252

Plate XVI: SEM Microstructure of 20% wt. CF composite

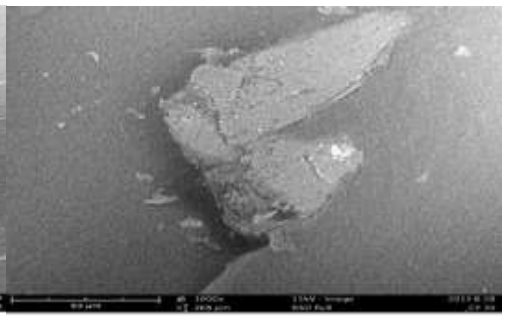


Plate XVII: SEM Microstructure of 30% wt. CF-GF hybrid composite

X- Ray Fluorescence Analysis

The mineral composition using XRF analysis is shown in Table 3 for coconut fibres, and the corresponding spectra for all conditions depicted in Figure 7. Chemical analysis by XRF shows that alumina (Al_2O_3), silica (SiO_2), CaO, K_2O, and P_2O_5 were found to be major constituents. Silica and alumina are known to be among the hardest substances. Some other oxides such as MgO, Fe_2O_3, and TiO_2 were also found to be present in traces. The presence of hard substances like Silica and Alumina suggest that coconut fibres can be used as particulate reinforcement in RLDPE matrix.

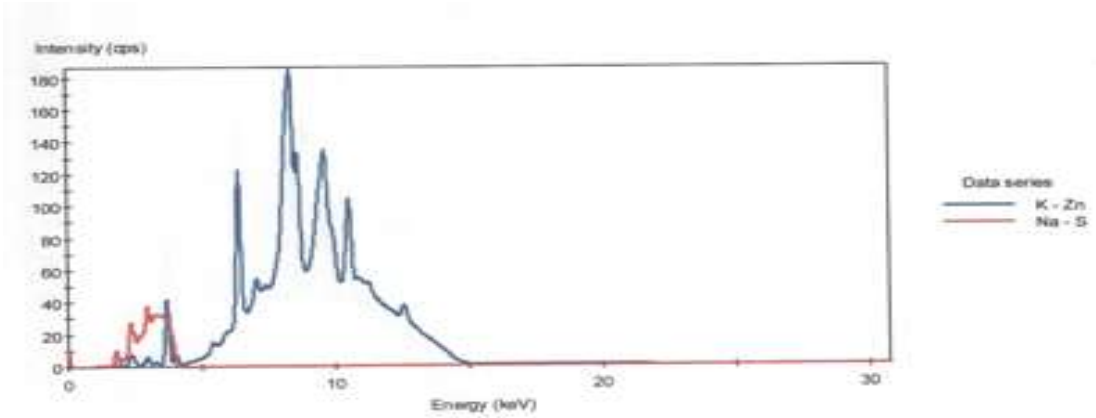


Figure 7: XRF Spectra for CF

Table 3: Chemical Composition of CF using XRF analyser

Element	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	Fe_2O_3
Concentration (wt %)	3.065	1.601	20.377	12.346	1.156	2.005	1.243	1.396	6.404

Comparative Analysis

In this section a comparative analysis is carried out between the properties of the hybridized and un-hybridized composite samples and the control sample (Toyota Camry 2009 model).

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 761-773 www.ijaem.net ISSN: 2395-5252

Table 4: Properties of Control Sample (Toyota Camry Bumper Material)

Property / Sample	Tensile Strength (MPa)	Bending Strength (MPa)	Water absorption (%)	Hardness value (HV) (HRB)	Impact Strength (J)	Density (g/cm^3)
Control Sample	13.74	12.10	0.51	8.60	2.05	1.30
Hybridized composite (15 Wt. % CF-GF)	13.1	11.96	2.92	7.06	2.91	0.89
Un-hybridized composite (15 Wt. % CF)	10.0	9.90	3.30	6.79	2.30	0.86

The density of the fibre reinforced composites is lower than that of the control sample for both the hybridized and the un-hybridized composites, which is good for weight reduction and energy savings (Table 4). However, the water absorption for the coconut fibre reinforced samples is higher than that of the control samples.

The mechanical properties such as hardness values, tensile, bending and impact strengths for the test samples are higher for the hybridized bumper samples than those of the un-hybridized samples, but slightly lower than those of the control sample (Toyota Camry Bumper material). However, the mechanical properties of the hybridized bumper samples fall within the recommended limits for standard car bumper [11,15].

IV. CONCLUSIONS

For this investigation, different experimental techniques have been used to characterize the microstructures and properties of hybridized and un-hybridized natural fibre reinforced low density polyethylene composites containing different volume fractions of coconut and glass fibres. From the results and discussions of the study, the following conclusions were drawn:

The work shows the successful development of composites of coconut fibre (CF) hybridized with glass fibre (GF) and reinforced low density polyethylene (RLDPE) binder by the simple compression molding technique.

The density of the composites decreased as the percentage of the fibres increased. Hybridization with glass fibre increased the density of CF/RLDPE composites slightly.

The percentage water absorption increased with increasing weight fraction of fibre reinforcement for both CF/RLDPE and CF-GF/RLDPE. Hybridization with glass fibre decreased the percent water absorption slightly.

The tensile strength of the developed composites decreased as the fractional weight of the reinforcement increased for both the hybridized and the un-hybridized composites. This was in line with the flexural strength behaviour. Both properties increased with the fibre length of the reinforcement fibres.

The Impact strength of the composite materials increased with increasing weight fraction of reinforcement fibres. Hybridized samples showed higher strength than the un-hybridized composites. Similar observation was made for their hardness properties.

The microstructure studies showed good interfacial bonding between reinforcement and matrix leading to good mechanical properties for the hybridized composites.

Based on the results obtained in this study, these grades of composites can be used in the production of low strength car bumper.

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