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Development and Properties Characterization of Polyethylene Based Composite Using Coconut Fiber

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Abstract

Composite material using coconut fiber to produce reinforced low-density polyethylene (LDPE) composite was produced for evaluating of the effect of varying fiber sizes on the mechanical (tensile, hardness, and impact strength), water absorption, and chemical resistance properties of the developed LPDE. Sample categories were prepared by varying the fiber sizes below 2.36 mm, ≥ 2.36 mm, and ≥ 3.35 mm at a constant 5% volume fraction loading. The water retting process was applied in the extraction and cleaning of the coconut fiber (or coir), while the developed composite material was prepared using the Hand layup Technique (HLT). The tensile and hardness properties were tested using the Universal Testing Machine (UTM) Model BDUM-2.5KN, while the impact properties were tested using the Izod Impact testing machine Model RI-300. The analysis of the water absorptivity showed that the developed composite materials have a low water absorptivity of 2% at fiber size loading below 2.36 mm. However, at higher fiber sizes of ≥2.36 mm and ≥3.35 mm loading, the water absorptivity increases significantly to 5.8% and 7.9%, respectively. Test results showed that the composites produced with fiber sizes less than 2.36 mm fiber loading has the most optimum combination of tensile and hardness properties, of 25.20Mpa and 22.96Mpa respectively but have the least impact strengths of 229 joules as compared to other sizes. It is recommended to use the hand layup technique for the production of low density polyethylene composites and this could further be used as an additive for the production of some lightweight polymer materials such as packing tools, furniture designs for tabletop, windows, door frames, cloth pegs, stool top, since its hardness, low strength, non-structural application, and moisture resistance analysis is within the acceptable limit of application for this purpose while eliminating pollution by using the waste sachets and nylon.

Keywords: Reinforced, Polyethylene, waste, Composite, Fiber, Strength.

1. Introduction

Composites are known as simply a combination of two or more constituent materials with different physical or chemical properties. They are made of multifunctional materials consisting of two or more chemically distinct constituents, having a distinct interface separating them. The discontinuous phase is embedded in a continuous phase to form the composite [1]. A polymeric blend is a material formed from the physical combination of at least two polymers. These materials are used in various technological applications due to the possibility of modifying several properties considering the main characteristics of the polymers in the blend and their mixing ratio [2]. Composite materials are continuously replacing traditional materials due to their excellent properties. A single large part made of composites can replace many metal parts. [1]. The importance of fibers in a composite material is to provide a framework of support and strength to the weak polymer matrix and the need to attain a set of desirable properties; the fibers must consist of properties such as high elastic modulus, good stiffness, and compressive strengths [3], [4].

Fiber-reinforced polymer composites are composites made from a polymer matrix that is reinforced with an engineered man-made or natural fiber [5]. However, this combination of plastic and reinforcement fiber can produce some of the strongest most versatile materials developed by technology like the low-density polyethylene grade to produce table tops, chairs, windows, door frames, etc. When combined, they produce a material with different characteristics from their original properties. Thus, the two main components within a composite are the matrix and the fiber [1], [7].

Moreover, the matrix is the base material, while the fiber is what reinforces the polymer material in the development of coir fiber composites and has recently gained attention due to its low cost, easy availability, low density, ease of separation, biodegradability, recyclable in nature [1]. Due to its strong yet flexible properties, Fiber reinforced polymer (FRP) can replace materials like wood, aluminum, granite, and steel [8]. [9] investigated the suitability of Coconut fiber reinforced polymer composite for the production of military helmets. One of the earliest uses of coir in Fiber Reinforced Polymer composites was found in the production of automobile parts [10], [11]. The growing

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concern about the environmental issues and development of advanced materials has forced us to utilize the natural resources for the development of fiber polymer composite, which is environmentally friendly and does not cause any harm in terms of pollution and decompose effortlessly [4], [5].

Polyethylene (PE) is a thermoplastic, polymeric material that can be softened and formed into useful shapes by the application of heat and pressure and which hardens when cooled. Polyethylene (PE) is a member of the poly-olefins family, which also includes polypropylene. As a group of materials, poly-olefins generally possess low water absorption, moderate to low gas permeability, good toughness and flexibility at low temperatures, and relatively low heat resistance. Polyethylene (PE) plastics form flexible but tough products and possess excellent resistance to many chemicals [9], [11], [12], [13].

Most synthetic polymers are produced from non-biodegradable petrochemicals. Using natural fiber–polymer composites in many applications is the most appropriate solution for integrating public concerns to reduce cost and time [10]. Over the years, natural fibers have been applied as reinforcement in composite materials; related to this project, Coil fiber (coconut fiber) was employed as reinforcement due to its availability and its rich fibrous mesocarp, which is a resource that can be used in fiber reinforced composites as a reinforcing material. Recently, polymer–matrix composites (PMC) have been of interest to industry and academia, especially in the areas of producing table tops, roof tiles, window, door frames, and clothes pegs [14]. Coir Coconut Fibers (CCF) main constituents are cellulose (42% wt), hemicellulose (0.25% wt), lignin (47% wt), ashes (2% wt), pectin (3% wt) and about 5% wt of moisture [15]. This is because of their superior properties such as high strength-to-weight ratio, good electrical insulation, ability to transfer load, and easy inexpensive processing that is used in a matrix blend [16].

In polymer composites, the matrix phase is the primary phase, which is a more ductile phase, and it holds the reinforcement that is the secondary phase. Reinforcements are usually stronger than the polymer matrix, which improves the mechanical properties of the polymer composite. When designed in a proper way, the new combined material exhibits good properties, which can be better than the individual material [17]. Continuous fiber reinforcement like silicon carbide (SiC), high strength carbon fibre is of low-cost, high-performance reinforcements for Aluminum matrix composites since it possesses high temperature stability and it is compatible with molten aluminum [1]. It is noted that fiber content coconut composite has improved the tensile strength but reduced the ductility of the matrix due to the better adhesion inside the composite. However, once the fiber content is increased, the adhesion inside the composite will also be reducing [17], [18].

The carbon-reinforced polymer material demonstrates excellent mechanical properties when a polymer (as a matrix) is mixed with different compositions of carbon fibers. The fiber-reinforced polymer in nature forms like straw and may work to improve the mechanical properties of the material to a great extent. Carbon fibre reinforced composites to low and high velocity impact loading was quite different [19], [20]. Fiber addition to polymers doesn't necessarily improve their wear resistance. It is worth mentioning that the performance of polymer matrix composite materials is different when subjected to different modes of wear [21].

Recently, public concerns about the environment, climate, emissions of gases, and energy consumption increase the focus on the use of natural and biodegradable materials in various applications [10]. In addition, the use of natural fibers from agricultural wastes is also in conformity with the re-use and reutilization of growing agricultural wastes. Thus, there is a need to develop a cheap method of obtaining composite material and a way of reducing the amount of waste in the environment. Judging from both material recycling and environmental protection viewpoint, the degradation procedure of plastic composites occurs at a much slower rate due to its durability and the chemical bonds that resist the natural degrading process. Many wastes such as plastic are deposited directly or indirectly into the marine environment and landfills [8]. However, valorization of these polyolefins is possible because they can be easily recycled by converting them into good performance polymer blends [9], [15]. Moreover, much work has been done on developing polyethylene composites by using various additives, fillers and reinforcement. Improvement of the interfacial bonding strength of the resulting material, as well as the effect of fiber loading has been the area of interest for scientists and academia, the size distribution of these fillers and fibers has not really been taken into consideration, hence the need for this study, which captures size variation in fiber addition, and its effect on the properties of the resulting composite.

Thus, this research is an attempt to use hand layup technique to develop low density composite using the abundance solid waste (Polyethylene sachets) and agricultural waste (Coconut fiber) in the environment since it is estimated according to the global economic growth that by 2050 the plastic waste produced will exceed 25 billion metric tons [16], [22].

1.1. PHYSICAL PROPERTIES OF POLYETHYLENE

Table 1 shows the physical properties of different polyethylene grades as cited in the work of [23].

2. MATERIALS AND METHODS

2.1. Fiber Preparation

The fiber materials used as reinforcing medium were extracts from the mesocarp of coconut fruit known as coir. The coconut fruit was locally sourced and purchased from Use-Offot Market at Nwaniba Road, Uyo, Akwa Ibom State. The coir (coconut) fiber was extracted from the coconut husks using the water-retting process, as discussed by [24]. The process involves soaking the coconut husk in water for two days to soften the bond between the exocarp and the mesocarp (coir) for it to be separated.

The coir obtained was then soaked again in water for three days to soften the hard coir. The extracted fibers were cleaned by beating off the husks lightly until the pithy substances were removed. De-waxing of the fiber was achieved by boiling and subsequently soaking in hot detergent for two hours. The fiber was then rinsed and dried.

After drying, the fibers were stored in a polyethylene bag [1].

Fiber size reduction was done by coarse grinding of the fiber in a milling machine, after which the coir fiber was separated into different sizes using a sieve shaker. Varying sieve sizes of less than 2.36 mm, ≥ 2.36 mm, and ≥ 3.35 mm were achieved. These varying sizes were then used in the composite formulation process.

Figure 1 shows the sample of soaked coconut husk used, Figure 2 shows the extracted coir used, and Figure 3 shows the coir when dried. Figures 4 to 6 show the different sizes of the ground fiber coir.

2.2. Sample Preparation

The composite material was developed based on the mixture of coconut fiber and Low-Density Polyethylene, which was categorized into five laminate volume weight percentages of the coconut fiber of varying sizes to the ninety-five weight percentage of the shredded LDPE (wastes polyethylene sachets). The weight of the test samples was measured manually using a digital weighing scale ($\pm$0.5), but the equivalent fiber weight fraction was obtained using the laminate formulae, which relate the fiber Volume Fraction (FVF) to the fiber Weight Fraction (FWF) [25].

$$\text{FWF} = \frac{P_f \text{ x FVF}}{P_m + (P_f - P_m) \text{ x FVF}} \quad (1)$$

Where;

FWF = fiber weight fraction.

FVF = fiber volume fraction

P_m = density of the polymer matrix.

P_f = density of the fiber (0.67g/cm^3), [26]

Equivalent matrix weight measurement was done using a digital weighing scale, and an equivalent weight of 4.2g for 5% volume fiber was deduced using the laminate formula. The composite formulation was based on 100g weight basis of the matrix and the reinforcement. 10 ml of tetra-isopropyl titanate (titanate coupling agent) was used as a binder for each trial formulation. Figure 7 shows the different samples and the sample weight measurement on a digital weighing scale.

Table 1. Physical Properties of different Polyethylene grades [23]

PROPERTIES	POLYETHYLENE GRADE		
	LDPE	MDPE	HDPE
Density	0.91 - 0.94 g/cm^3	0.926 - 0.94 g/cm^3	0.941 - 0.965 g/cm^3
Melting point	105 – 115 ºC	126 – 137 ºC	128 – 180 ºC
Tensile strength	0.9 – 13 Mpa	13 – 30 Mpa	20 – 40 Mpa
Flexural strength	6 – 20 Mpa	20 – 35 Mpa	25 – 42 Mpa
Hardness	20 – 30 Mpa on shore D scale	35 – 45Mpa on shore D scale	45 – 75Mpa on shore D scale
Impact strength	12 – 15 kJ/mm^2	20 – 32 kJ/mm^2	35 – 47 kJ/mm^2
Thermal conductivity	0.33 – 0.40 W/m.k	0.35 – 0.45 W/m.k	0.42 – 0.52 W/m.k

Figure 1. Soaked coconut Husk

Figure 2. Extracted coir

Figure 3. Dried coir

Figure 4. less than 2.36 mm size

Figure5. ≥ 2.36 mm size

Figure 6. ≥ 3.35 mm size

Figure 7. Samples weight measurement

Table 2. Sample Measurements ratios for composite formulation

Sample	Fiber size (mm)	LDPE weight (g)	Fiber weight (g) (5% laminate volume)
1	Less than 2.36 mm	95.8	4.2
2	≥ 2.36 mm	95.8	4.2
3	≥ 3.35 mm	95.8	4.2

2.3. Development of the Composite

The hand lay-up technique was employed in the fabrication of the composite material. The method entails subjecting the shredded polyethylene (waste polyethylene sachets) to complete mixing with the desired formulation ratio of 5 percentage volume fiber, together with a titanate coupling agent; the resulting mixture was heated within the melting temperature range of 106 ^{o}C to 112 ^{o}C, until the polymer melts and flow. The mixture was then poured on a mold, and a roller was used to roll on the surface of the composite inside the mold. Curing of the polyethylene matrix composite occurred for 2 to 3 hours [21]. Figure 8 shows the fabricated steel mold of 140.5 mm x 60.5 mm x 10 mm size, while Figure 9 shows the developed composite inside the mold.

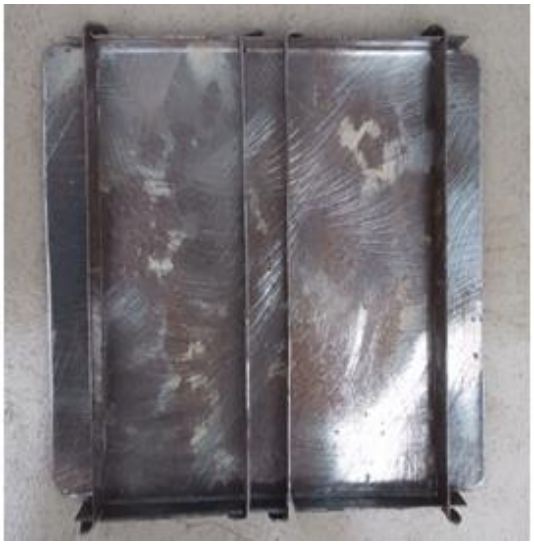

Figure 8. 140.5mm x 60.5mm x 10mm steel mold

Figure 9. Developed composite on the mold

2.4. Testing Procedures

2.4.1. Tensile Test

The tensile test of the specimen was prepared according to the American Society for Testing and Materials [27] standard. The testing process involves placing the test specimen in the testing machine and applying tension to it until it fractures. The (10 mm thick with a width of 16 mm) tensile tests of the composites were carried out using the Universal Testing Machine (UTM), Model BDUM-2.5KN. The speed of the tensile testing machine was set to 5 mm/min, and a gauge length of 40 mm was used. The specimen dimension was 10 mm thick with a width of 16 mm [27].

2.4.2. Hardness Test

The hardness properties of the composites were determined by a three-point compression method using the Universal Testing Machine (UTM), Model BDUM-2.5KN, with a standardized load capacity of 2.5KN according to [28] standard. The testing process involves placing the test specimen in the testing machine and applying a compressive force of 2.5KN to it to check and evaluate its hardness. The tests were carried out at a room temperature of 25 ^{o}C with a crosshead speed of 3 mm/min [28]. Figure 10 shows the testing machine used to test the hardness of the composite.

Figure 10. The Universal Testing Machine (UTM)

2.4.3. Impact Test

The impact test of the specimen was prepared according to the required dimension following the [29] standard. The Izod impact testing machine, Model RI-300, with a load capacity of 300 Joules, with 2 Joules step graduation, was used. This test was done by striking the test specimen with a standardized impact load capacity of 300 J while the specimen was held securely at each end. The energy absorbed by the specimen was determined precisely. A standard Izod impact test specimen dimension of 70 × 10 × 11 mm was adopted [29]. Figure 11 shows the impact testing machine used.

Figure 11. Izod / Impact Testing Machine

2.4.4. Water Absorption Test

The moisture absorption test was performed in accordance with [30] standards. The weight of the samples measuring 20g, 20.6g, and 22.4g was taken before immersion in water. After an exposure period of 5 days (120 hours), the specimens were removed from the moist environment, and all surface moisture was removed. The specimens were then reweighed to the nearest 0.001 mg [30]

The percentage weight gains of the samples were then measured by using the following equation:

$$\% M = \frac{(Wt - W_o) \times 100}{W_o} \quad (2)$$

Where;

% M = weight gain in percentage.

W_t = Weight of sample after immersion.

W_o = Weight of sample before immersion.

2.4.5. Chemical Resistance Test

This study selected two test conditions to investigate the short-term effect of exposing the fabricated coconut fiber-reinforced polyethylene-based composite to acidic and alkaline mediums. H_2SO_4 and NaOH were used as the acidic and alkaline testing solutions. The effects of the two solutions on the developed composites were determined after the exposure time [31].

The following signs were evaluated during the contact time of exposure:

- Discoloration
- Swelling
- Weight loss
- Degradation (wearing).

Exposure periods of 120 hours were considered. The samples not exposed to the acid and alkaline solution were used as control samples.

3. RESULTS AND DISCUSSION

3.1. RESULTS

Tables 3(a), (b), and (c) show the mechanical properties of the developed composite, while Table 4 shows the water absorption capacity, and Table 5 highlights the chemical resistance properties of the developed composite at different fiber sizes of constant 5% laminate volume loading.

Table 3(a). Tensile Strength Distribution of the Developed Composites

Sample	Fiber size (mm)	Notch Depth (mm)	Length (mm)	Weight (g)	Tensile strength (Mpa)
1	Below 2.36 mm	10	16	20.4	25.20
2	≥ 2.36 mm	10	16	19.5	23.15
3	≥ 3.35 mm	10	16	20.8	24.04

Table 3(b). Degree of Hardness of the Developed Composites

Sample	Fiber size (mm)	Thickness (Diameter) (mm)	Length (mm)	Weight (g)	Degree of Hardness (Mpa)
1	Below 2.36 mm	17	15	11.4	22.96
2	≥ 2.36 mm	10	15	9.0	22.90
3	≥ 3.35 mm	13	15	9.8	21.84

Table 3(c). Impact strength distribution of the developed composites

Sample	Fiber size (mm)	Thickness Diameter (mm)	Length (mm)	Notch Depth (mm)	Weight (g)	Impact strength (Joules)
1	Below 2.36 mm	10	70	11	11.3	229
2	≥ 2.36 mm	10	70	11	10.1	230
3	≥ 3.35 mm	10	70	11	13.8	232

Table 4. Water absorption capacity of the developed composite

Sample	Fiber size (mm)	Weight Before immersion (g)	Weight After immersion (g)	% weight gain (%)
1	Less than 2.36 mm	20	20.4	2%
2	≥ 2.36 mm	20.6	21.8	5.8%
3	≥ 3.35 mm	22.4	24.19	7.9%

Table 5. Chemical resistance capacity of the developed composite

Sample	Fiber size (mm)	Contact Time Evaluations			
		Discoloration	Swelling	Weight loss	Wearing
1	Less than 2.36 mm	Not Evident	Not Evident	Evident	Not Evident
2	≥ 2.36 mm	Not Evident	Not Evident	Evident	Not Evident
3	≥ 3.35 mm	Not Evident	Evident	Evident	Not Evident

3.2. DISCUSSION OF RESULT

3.2.1. EFFECT OF VARYING FIBER SIZES ON THE MECHANICAL PROPERTIES OF THE DEVELOPED COMPOSITE

3.2.1.1. Tensile Strength: Table 3(a) shows the average tensile strength of the developed composite at varying sizes. It can be seen that the composite produced with a fiber size of less than 2.36 mm had the highest tensile strength of 25.2 Mpa, as shown in Figure 12. As compared to pure LDPE, the tensile strength distribution of the developed composite was above the range of (0.9Mpa to 13Mpa) as available in Literature [23]. Although the tensile strength of the pure LDPE generally increases with the incorporation of coir fiber, this increasing trend was randomly distributed, as the tensile strength increased with the addition of 5wt% fiber but tends to decrease as fiber sizes increase. This haphazard trend encountered is attributed to the fact that the tensile strength is affected by the fiber volume fractions, degree of adhesion between the filler and the matrix, level of dispersion of the filler and matrix, and surface-related defects. This shows a similar finding by [32]. The decrease in tensile strength may be explained due to poor wettability leading to a weak interface. In principle, a lack of proper wetting between the fiber and the matrix could lead to the formation of voids at the fiber-matrix interface, which may significantly reduce the tensile properties, as discussed by [21], [34]. Tensile test strength is an important property to determine the mechanical performance of composites in some mechanical application The formation of small voids due to fiber withdrawal (i.e pull out serves as preferred sites for cracking propagation, thus reducing the tensile strength. Many studies [11], [17], [33] have confirmed that coconut fiber improves the tensile and impacts strength. Figure 12 shows the tensile strength of the developed composite at a constant 5% fiber loading of varying sizes.

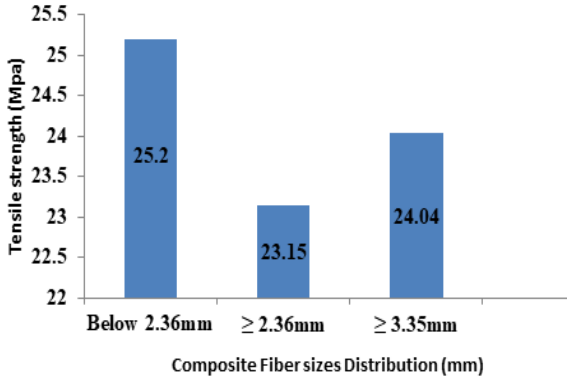

Figure 12. Tensile strength of developed composite at constant 5% fiber loading of varying sizes

3.2.1.2. Degree of Hardness: The average Hardness degree of Coir-LDPE composite as a function of varying fiber sizes at a constant 5% fiber volume fraction is presented in Table 3(b). The composite with less than 2.36 mm fiber size exhibits a maximum hardness of 22.96 Mpa, while a minimum hardness of 21.84 Mpa was observed for fiber size greater than or equal to 3.35 mm when subjected to compression, as shown in Figure 13. The high value of hardness was observed with the composite with less fiber size, but this decreases with an increase in fiber sizes for the other samples evaluated. This may be due to insufficient filling of the melted LDPE resin into the reinforcing natural fibers during composite processing. Thus, hardness is a material's resistance to permanent surface deformation (i.e dent) as could be determined and obtained by Universal Testing Machine [10]. Figure 13 plot showed the degree of hardness of the developed composite at 5% fiber loading of varying sizes.

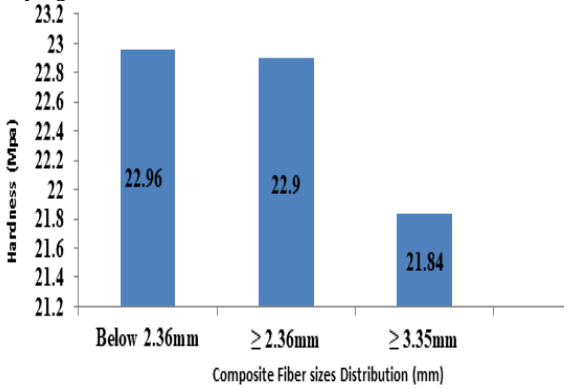

Figure 13. Degree of Hardness of developed composite at constant 5% fiber loading of varying sizes.

3.2.1.3. Impact Strength: The impact strength of the various Coir-LDPE composites samples evaluated at varying fiber sizes, at constant 5% Fiber volume fractions, are presented in Table 3(c). The Coir-LDPE composite with ≥ 3.35mm fiber size loading exhibits the highest impact strength of 232 Joules; this verified the statement by [33] that "low-density polyethylene are flexible polymer matrix, which causes the composites made with this material to have high-impact strength among unfilled samples." Similarly, less fiber sizes of ≥ 2.36mm and below 2.36 mm experienced a decrease in impact resistance capacity, as shown in Figure 14. In comparison to the pure LDPE, the incorporation of coir fiber significantly increased the impact strength of the developed composite. Here, the impact strength of the developed composite is observed to be at maximum and above that of pure LDPE, as available in the literature [20]. Figure 14 presents the Impact strength of the developed composite at a constant 5% fiber loading of varying sizes. Impact strength test is one of the tests that indicate to what extent composites can absorb shocks before breaking. The propagation and distribution of micro-cracks depend directly on the type of matrix and fibers that are used in the composites [10].

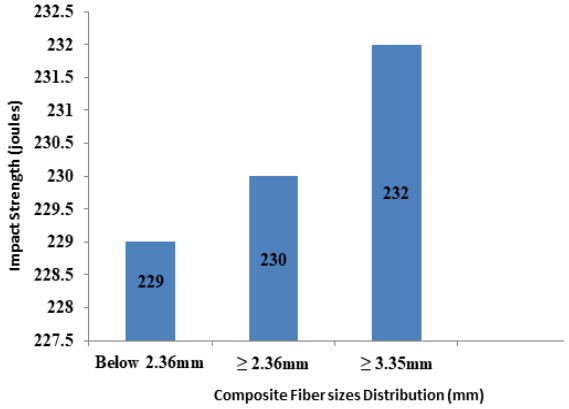

Figure 14. Impact strength of developed composite at constant 5% fiber loading of varying sizes

3.2.2. EFFECT OF VARYING FIBER SIZES ON THE WATER ABSORPTION CAPACITY OF THE DEVELOPED COMPOSITE

The water absorption behaviors of the Coir-LDPE composite specimens were measured at room temperature of 25ºC for a maximum period of five days, as shown in Table 4. It can be observed that the moisture absorption generally increased with increasing fiber sizes as this was reported [6] After an extended immersion time of 120 hours, the sample with a sieve size ≥ 3.35mm experienced significant water retention, leading to an increment in the weight of the sample. Although LDPE usually has low water absorption capacity, i.e., insignificantly small, this confirms the hydrophobic nature of polyethylene. From this study, the Coir-LDPE composite sample with ≥ 3.35mm fiber size showed the maximum water absorption. Also, specimen swell was observed in the composites with ≥ 3.35mm fiber size when exposed to the wet environment. This swell can be attributed to the presence of highly interconnected pores created within the developed composite as a result of the increased size of the fiber used during processing, leading to micro-cracks, which were also noticed in the developed LDPE composite matrix. This may have led to the large transport of water through the fiber-matrix interface. This showed similar findings by [1], [2], [35]. Hence, fiber swells, and micro-cracks are the main reasons for the significant water absorption by the 3.35mm coir-LDPE composites as compared to other sizes. Figure 15 shows the estimation of the water absorption capacity of the developed composite calculated.

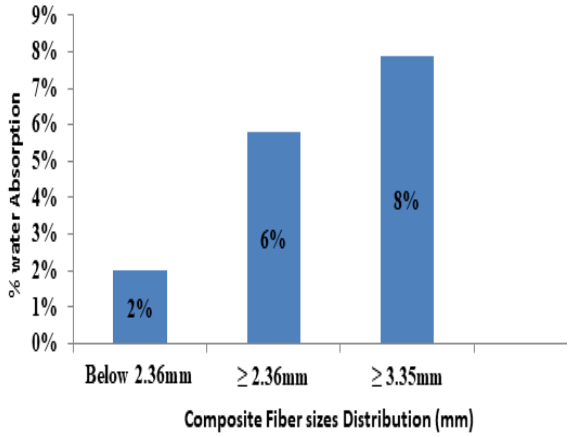

Figure 15. Estimation of Water Absorption Capacity of developed composite

3.2.3. EVALUATION OF THE CHEMICAL RESISTANCE CAPACITY OF THE DEVELOPED COMPOSITE

Analysis of the overall chemical resistance of the developed composite is presented in Table 5. After the stipulated contact time of exposure for 5 days (120 hours), it was discovered that the developed composite at varying fiber sizes was “Not Evident” to discoloration and wearing but proved “Evident” to loss of weight across the board for all samples evaluated. The sample produced with fiber sizes less than 2.36mm and ≥ 2.36mm also proved to be “Not Evident” of swelling during the contact time evaluation, but the sample produced using the ≥ 3.35mm size experienced appreciable swelling evidence. This might be due to the presence of highly interconnected pores created within the developed composite as a result of the increased size of the fiber, leading to micro-cracks, which were also noticed in the developed LDPE composite matrix [10]. This might have led to the transport of chemical reagents used through the fiber-matrix interface.

Figure 16. Less than 2.36 mm Fibre size

Figure 17. ≥ 2.36 mm Fibre size

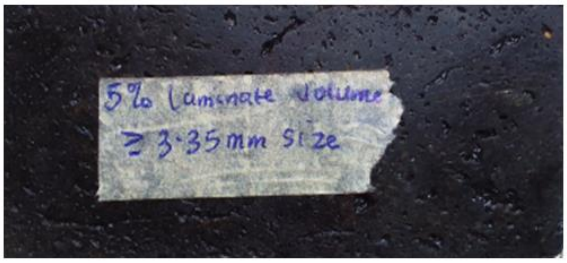

Figure 18. ≥ 3.35 mm Fibre size

Figure 19. Fractured specimen from tensile tests

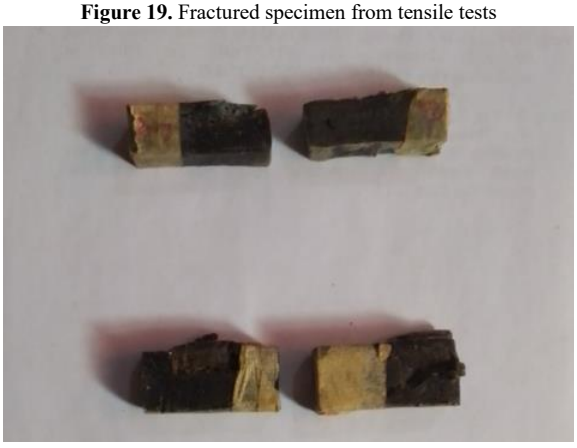

Figure 20. Fractured specimen from impact test

Figure 21. Fractured Specimen from hardness test evaluation

Figure 16 is less than 2.36 mm fibre size composite with 5% laminate volume while Figure 17 is the fibre size of greater than or equal to 2.36 mm composite with 5% laminate volume produced looks like. Figure 18 showing fibre size of greater than or equal to 3.35 with 5% laminate volume produced. Figure 19 is the fractured specimen from tensile strength tests while Figure 20 is the fractured specimen from the impact test carried out and Figure 21 is the fractured specimen from the hardness test evaluated.

4. CONCLUSION

Applying the hand layup processing technique makes it possible to develop coconut fiber-reinforced low-density polyethylene composite material. The mechanical properties, which include tensile, hardness, and impact strengths, were tested and evaluated successfully using the universal and Izad impact testing machines. Generally, the results showed that the composites produced with fiber size less than 2.36 mm fiber loading have the most optimum tensile and hardness properties but the fewest impact strengths compared to other sizes. Thus, the following conclusions were drawn from the study:

- the average mechanical properties of the developed composite fiber are as follows: the tensile strength is 24.13 MPa, the hardness is 22.57 MPa, and the impact strength is 230.33 J, which provides a comprehensive understanding of the material's performance,
- the water adsorption capacities of the different composite fibers are 2% for the below 2.36 mm fiber size, 5.8% for the $\leq$ 2.36 mm fiber size, and 7.9% for the $\geq$ 3.35 mm fiber size, and
- also, the chemical resistance capacities of the developed composite fibers were not evident for discoloration, wearing, and swelling (except for the $\geq$ 3.35 mm fiber size) and evident for weight loss for all the fiber sizes.

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