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Analysis of Sustainable Diss Fibers Recycled Composite for Building Component Improvement

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ABSTRACT

In the building industry issues relating to sustainable development using renewable, degradable and less energy-intensive materials have generated extensive research. The choice of material, particularly recycled composites has substantial influence on durability, structural integrity, energy performance of the building, as well as, impact on the environment. There is growing interest in the use of dissfiber amongst various materials as reinforcement in sustainable engineering technologies. This paper aims to reduce waste management and generate wealth by investigating the novelty of combining plastic waste bottles and polypropylene reinforced with diss to produce hybrid composite The objectives of the project are to create a polymer composite reinforced with Jute mallow fibres, assess the viability and advantages of incorporating sustainable materials, and investigate the mechanical characteristics and structure of the created composites. The procedure entails sun-drying and turning Diss stem fibres into fibres after treating them with a 5% NaOH solution to improve fibre quality. After that, a two roll mill is used to compound these WBP fibres with natural rubber and polypropylene, and a hydraulic press is used to mould the mixture. According to ASTM guidelines, tests were conducted on mechanical attributes such as tensile strength, hardness, flexural wear resistance, and compression set. Initial findings show that adding Jute mallow fibres significantly increases hardness and wear resistance, especially when the filler proportion is 20%. This study aims to broaden plantfiber utilization in the sustainable production of polymer for construction applications

Key word; Building component, Recycled composite, Polymer matrix's, Sustainable Diss fibres

I. INTRODUCTION

The growth in the construction industry has created a demand for building components with enhanced properties such as strength, stiffness, lower density, cost-effectiveness, and improved sustainability. Composites are increasingly gaining popularity across multiple industries as research and development demonstrate their effectiveness in replacing inefficient materials. In this context, the quest for innovative building solutions that conserve non-renewable resources has spurred extensive research aimed at developing sustainable building components based on easily renewable natural raw materials. This, in turn, reduces the cost of building components such as PVC ceilings, panel doors, and building service components. There is a growing interest in the utilization of vegetable materials as aggregates and/or fiber reinforcement in lightweight composites known as "green" composites/concretes for sustainable construction. Composite materials are a combination of two or more constituents, with one present in the matrix phase, and the other in particle or fiber form (Clyne, T.W.; Hull, D., 2019). The incorporation of natural or synthetic fibers in composite material fabrication has revealed significant applications across various fields, including construction, mechanical engineering, automotive, aerospace, biomedical, and marine (Monteiro et al.,2018). These composite structures can be customized to meet specific application requirements. As the demand for environmentally friendly construction materials grows, manufacturers are researching methods to recycle composites and extend their service life. In recent years, the use of composite products has increased, particularly in the automotive and construction industries, which now consume nearly half of all manufactured composites. Consequently, the issue

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of composite recycling and usage has become increasingly important (Zaid et al., 2022).

Natural fibers as fillers in thermoplastics are in high demand due to their low density, excellent thermal insulation and mechanical properties, minimal impact on processing equipment, abundant availability and affordability, improved surface finish of molded composite parts, renewable nature, and easy disposal. These versatile characteristics make natural fibers superior alternatives to conventional fillers like aramid and glass fibers. Also, various types of vegetable waste materials, including flax, hemp, coir, jute, bamboo, palm, kenaf, and others, after processing, have been utilized in particle form as replacements for sand and aggregates in concrete and mortars (Gavrilescu et al., 2009; Pereira et al., 2019; Sassoni et al., 2014).The main objective of this work was to investigate the potential use of Dissfibres as reinforcement of providing an alternative solution to an environmental approach. In order to mitigate the inhibitory effect exerted by vegetable particles on hydration reaction of binder, due alkali-dissolved components, the Diss fibers were treated with hot water. The effect of Diss fibers has been assessed by means of mechanical properties, such as compressive and flexural strengths.

The aim of this research is to develop and investigate the mechanical and wear properties of hybrid composite materials using natural diss fibers (jute mallow) as the reinforcing materials in recycled waste plastic bottles and polypropylene as the matrix via compression moulding technique.

II. MATERIALS AND SPECIMEN PRODUCTION

The Diss stem (Ewedu) Jute mellow was obtain from a local restaurant as waste the stem was treated by immersion in distilled water with the addition of 5% of NAOH for 24 hours them was removed and cleaned and was sun dried for a period of three weeks, and them processed into fibers

Fig 1.0Diss fiber stem

process Diss fibers

polypropylene was obtained from Eleme Petrochemicals, Port Harcourt while tetramethylthiuram disulphide, mercaptobenzothiazolesulphenamide, stearic acid, sulphur, zinc oixide, paraffin wax, trimethylquinoline were made by British Drug House and were obtained from Rovet Chemicals, Benin City. The recycled waste plastic were obtain from waste bin figure 2, 0 shows the polypropylene and waste plastic bottles (wpb)

Fig 2.0 polypropylene Waste Plasticbottles (WPB)

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2.1 PROCESSING OF COMPOSITES

Compounding of waste plastic bottles and polypropylene with filler was based on the sample constituent make up showed in the Table 2.1

Table 2.1

Ingredient	Parts per hundred rubber (Phr)
Polypropylene/waste Plastic bottles	100
Filler	Variable (5 - 15)
Zinc Oxide	5.0
Stearic acid	2.5
Sulphur	1.5
MBTS	1.5
TMTD	3.5
Paraffin Wax	5.0

A batch factor of two (2) was used.

Waste Plastic Bottle (WPB)

PVC Plastic Waste bottle material is extremely light, with a specific weight of 2.7 (g/cm3). Plastic Bottle is manufactured all over the world. PVC waste plastic bottles main property is its highly durable and resistive to deterioration.

2.2 COMPOUNDING OF POLYPROPYLENE AND WASTE PLASTIC BOTTLES (WPB)

The compounding of polypropylene and waste plastics bottles was carried out in accordance to ASTM D4295-89 using the two-roll mill maintained at 1600C to avoid crosslinking during mixing. The process involved preheating the rolls of a two-roll machine prior to the introduction of polypropylene pellets and subsequently crumb waste plastic bottles between the moving roll which rotate counter wise for mastication to take place. After about 5mins, the additives were added for effective compounding. Sulphur was added last because it introduced 3-dimensional network structure into the plastic compound. The sequence is presented below in Table 2.0The control specimen consists of 75% waste plastics bottles and 25% polypropylene without diss table 2.1 for formulation table

Mixing Steps and Time in Compounding

Table 2.0

Mixing Step	Time (min)
Polypropylene Melting	5.00
Waste Plastic bottles Mastication	5.00
Addition of Stearic Acid	1.00
Addition of Zinc Oxide	1.00
Addition of Filler	5.00
Addition of MBTS	1.00
Addition of TMTD	1.00
Addition of Paraffin Wax	1.00
Addition of Sulphur	2.00
Total	**22.00**

Figure 3.0 two roll millfigure 3.1 Compression molding Machine

Formulation Design for Compounding Table 2.1

S/N	SAMPLES	wpb(g)	pp(g)	DF(g)
1	**A(CONTROL)**	**75**	**25**	**0**
2	**B**	**75**	**20**	**5**
3	**C**	**75**	**15**	**10**
4	**D**	**75**	**10**	**15**

KEY. PP Polypropylene, WPB waste plastic bottles, DF Dissfibres

III. EXPERIMENTAL TESTING

The tensile properties were determined on a universal tensile tester model at a cross speed of 55mm/min using dumbbell test pieces of dimension (80 × 10× 3.50mm). The tensile test was conducted on a universal testing machine in accordance with ASTM D412. A dumbbell sample of known dimensions was loaded into tensile grips of the tensometer and clamped into the two jaws of the machine with each end of the jaws covering 30mm of the sample with the extensometer attached. The test begun by separating the tensile grips at a constant speed depended on sample dimensions. It ranges from 0.05 – 20inch per minute and for 30secs - 3mins. Readings were obtained when the sample under tension were yielded.

The Rockwell hardness was used to study the vulcanizate resistance to indentation by the indenter. The Durometer consists of 12.7mm foot diameter, an operating stand with a mechanically controlled rate and 1kg mass centered on the axis of the indenter in accordance with ASTM D2240. The sample was placed horizontally with its major axis, the area in which the hardness was measured under the Durometer indenter by means of V-block. The hardness measurements were taken vertically while the presser foot was applied without shock until the full force was in contact with the wheel and the sample surface. Readings was taken at 5sec interval after the presser foot was in contact with the wheel surface.

Flex Fatigue measurement was carried out in accordance to ASTM D430 using the flex tensometer machine which functioned by inducing surface cracking of the moulded samples. A specified mean load which may be zero and an alternating load were applied to the specimen, and the number of cycles required to produce failure (fatigue life) was recorded. The tests were repeated with identical samples at various fluctuating loads. The loads may be applied axially in torsion or in flexure depending on the amplitude of the mean and cyclic loading. Net stress in the sample may be in one direction through the loading cycles or may reverse direction

IV. RESULTS AND DISCUSSION

4.1 COMPRESSIVE STRENGTH OF REINFORCED SPECIMENS

The result obtain from the compressive test for the various samples The results in table 4.1 indicated that the addition of Diss fibers serves to decrease compressive strength from 31.7428, for Control Specimen, to 23.0658 for specimen D containing Diss fibers of 15% . It corresponds to reduction of approximately 31%. The decrease in strength is related to the mechanical properties of Dissmaterials. The roughness surface of fibers may be the important limiting factor that leads to interfacial bond defects between particles and matrix. It is assumed that mechanical strength of specimen is opposite to its unit weight. In addition, the decrease in compressive strength is related to porous structure of specimen

Table 4.1 Compressive strength of polymer fibre composite samples

Sample	**DF Fraction (%)**	**Compression Set (%)**
A	0	31.7428
B	5	31.0050
C	10	28.7506
D	15	23.0658

4.2 Hardness test

Figure 4.2 displays the polymer's hardness characteristic. It has been discovered that the Hardness values rise as the number of fillers in the polymer composite's matrix increases. The Following figure illustrates the significant rise in hardness values. This rise in hardness value Could be attributed to the dissfibre filler, which, when compared to the unreinforced sample, increased the crosslinking in the matrix. The hardest properties are found in the matrix with 15% filler. sample A (control) had 42.2051, the 5% reinforced sample (B) had 48.0098, the 10% reinforced polymer (C) had 46.5518,and the 15% reinforced (D) had 52.7208 This outcome is displayed in Table 4.2. The hardness response shows a similar trend pattern with empirical study in like manner, a study by Adeolu et al. (2022) which investigated the mechanical and morphological study of Polypropylene reinforced with snailshell and kenaffibre. The hardness investigation displayed an increase in its response with increasing content of both the kenaf and the snail shell particulate attributing this trend to the fibre interlink within PP matrix.

Table 4.2. Hardness of polymer matrix'sfibre composite samples

Sample	DF Fraction (%)	Shore "A" Hardness (10sec Value)
A	0	42.2051
B	5	48.0098
C	10	46.5518
D	15	52.7208

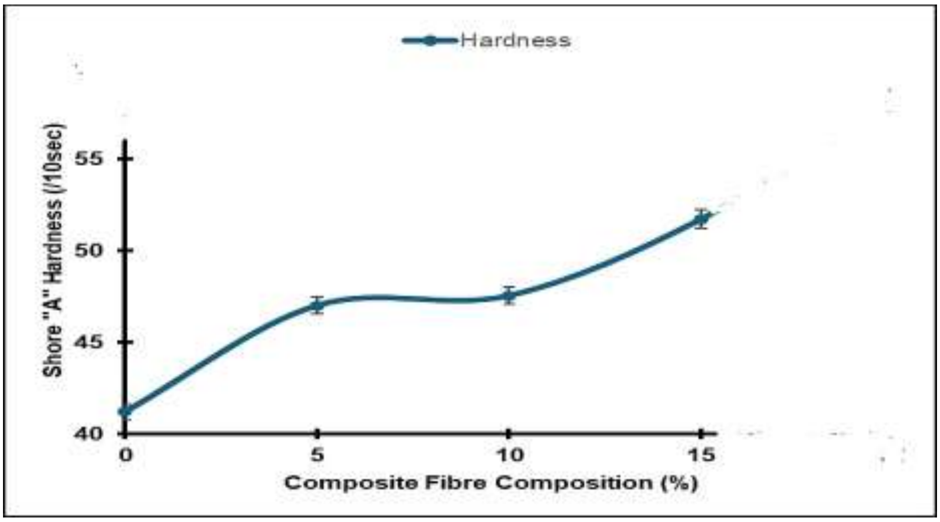
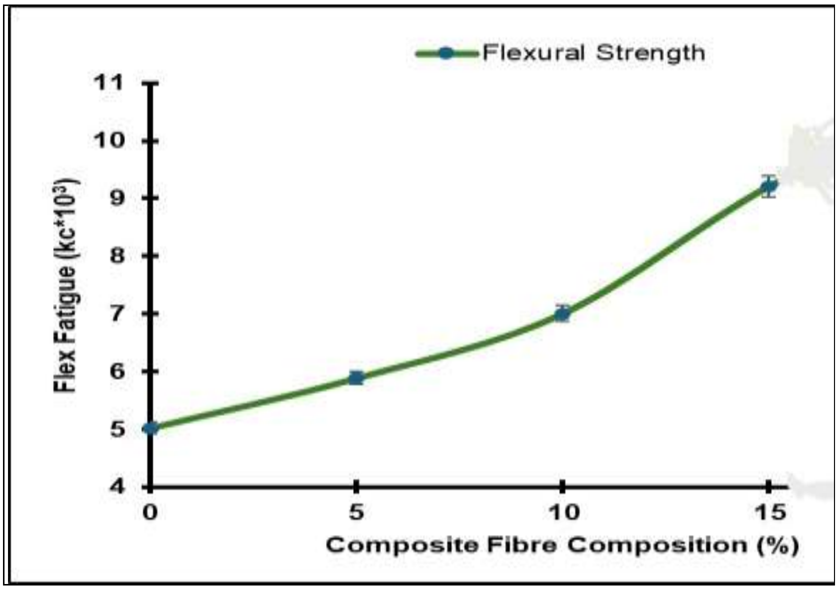


Fig 4.2 Hardness value plot of developed samples

4.3 Flexural strength of reinforced specimens

The greatest tensile stress a composite can bear while bending without failing is represented by its flexural strength. Figure 4.3 illustrates how the weight percentages (0%–15%) of Dissfibres affect the stress-strain curves of polymer composites used in bending tests. As the percentage of Diss increased in comparison to the control specimen without Diss, there was a significant difference in the (stress-strain) behavior. Additionally, the flex fatigue increased from 5.0211 kc*103 for the control sample to 9,2126 at 15wt.%, representing a 83.4%increase, as indicated in fig 4.3 The upward trajectory of the flexural strength is not a strange phenomenon, as it has been observed in similar studies, for polymer composite.



V. CONCLUSIONS

In this study, experiments have been performed to investigate the feasibility and mechanical Properties of polymer reinforced with Dissfibers procedure was conducted throughout compressive/flexural strengths, and the examination of elasticity behavior. These properties are also compared with those obtained with specimen without Diss fibers (control sample) It was possible to effectively create hybrid-reinforced polymer composites with 0%, 5%,10%,and 15% Diss reinforcement. The mechanical (tensile strength), hardness, and flexural wear resistance of the created composite qualities are additionally contrasted with those obtained with specimens without fibre addition (control), as demonstrated by the characterization of the produced polymer composite.

i. The Investigation of the hardness, flexural and abrasion characteristics shows that the percentage weight fraction of the reinforcements (D.F) has a significant effect on the Hardness of the composites. The blending has significantly improved the mechanical properties of the develop composites which can withstand the strength required in Building component application.

ii. When the filler is added, mechanical characteristics including compression set, tensile strength, and tensile module elongation decrease in comparison to the control Sample.

iii. Composite was produced from recycled waste (dissfibers) and waste plastics bottle Thus, the utilization of waste will help to convert waste to wealth.

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