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Hybrid Effect of Kenaf/Sisal based hybrid composites: Investigate the Mechanical properties like Tension, Flexural and Impact

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ABSTRACT

Because of sustainability as well as resource preservation considerations, a push for cheap, lightweight materials has rekindled a desire to create recycled materials which can substitute non-recyclable as well as ecologically unfavourable components in polymer nanocomposites. The mechanical performance of a mixed layer formed of polyester supplemented with a combination of sisal and kenaf fibres was investigated in this research. The laminate was created by manual lay-up at different fibre weights whilst keeping a constant fibre mix proportion of 50/50. Polymers were also made with a continuous fibre weight of 18% as well as a fibre mix proportion ranging from 0 to 100%. The manufactured materials were then tested for bending, tension, compression, as well as impacting characteristics in accordance with ASTM specifications. The findings confirmed that at a fixed fibre concrete mixture of 65/35, mechanical characteristics improved even as fibre wt.% rose from 2.5 to 10%. A good increase in flexural, tension, as well as compression characteristics was seen at a fixed fibre weight percentage even as the fibre mix ratio changed from 0 to 65%, with the highest bargains at a natural fibre proportion of 65/35. The ongoing employment reveals that combining sisal with kenaf fibres for polymer combination manufacture results in composite samples with good mechanical characteristics.

Keywords: Sisal Fiber; Kenaf Fiber; Mechanical Properties; Impact strength; Polyester Matrix.

INTRODUCTION

There has been a considerable trend in the utilisation of natural fibres in polymeric composites during the last few generations. Such materials have several benefits over man-made fibers, including minimal wear rate, easy processing, lower cost, accessibility, as well as renewability. Biocomposites, like cannabis, cotton, flaxseed, hemp, as well as agave, are among the most commonly used natural products in the world. One explanation for this increasing attention is also that natural materials have a better bond toughness and a comparable stiffness to fibreglass [1,2]. Such natural fabrics, with these qualities and cheap resources, should potentially deliver acceptable unique advantages and stiffness at a lower price. Natural materials are classified according to their source, i.e., if they are produced by plants, mammals, or minerals. As per university researchers, cellulose fibres are among the most prevalent organic materials utilised as reinforcements in fibre composites. Bast fibres, leaves or tough fibres, seeds, fruits, lumber, corn stover, as well as various grassland fibres are examples of plant fibres. The molecular structure and composition of natural fibres are quite complex [3]. Cellulose fibres are natural synthetic fibers. The fibres are made up of a substrate of stiff, crystalline, usually collected, unstructured phenol as well as lignocellulose. With the exception of silk, most botanical fibres are made from lignocellulose, phenol, wax, and a variety of moisture chemicals, with cell wall, glucans, and lignocellulose being the most abundant.

Kenaf is indeed a fibrous material that is employed for reinforcing in Polymeric Composites. Kenaf was already discovered to be a major fibre source for polymers as well as other chemical inputs. Under a variety of meteorological circumstances, Kenaf is very well recognised as a cellulose resource both with social and financial benefits. In three months, it may attain a height of more than 2.5 m as well as a base diameter of 6 cm. This assertion is corroborated by prior research, which indicates that under ideal environmental circumstances, growth can approach 11 cm/day [4,5]. Kenaf averaged Rs110 per kilogramme in 1996 and ranged from 250 to 360 per kilogramme in 2010. In terms of resource usage, 1 kilogramme of kenaf requires 16 MJ of fuel to create, but 1 kg of fibreglass requires 53 MJ. The kenaf tree is made up of numerous excellent benefits, each of which consists of different useable parts. Numerous variables can influence the production and content of various plant components, such as cultivars, direct seeding, photophobia, vegetation period duration, unit densities, and crop age. Kenaf filaments are made up of separate individual strands that range in size from 3 to 4 mm. Filaments and single fibre characteristics might vary based on the fiber's origin, length, separation procedure, and chronology [6]. The stalk is spindle-shaped as well as upright, with an outermost surface (bark) as well as a pith. The stems may be easily separated from the peel and pith using chemical or microbial fermentation. The peel accounts for 35–40% of the dry mass of a stem with a fairly thick architecture. The pith, on the other hand, is timber and constitutes all the other 50–65% of a stem. The patterning in the nucleus is nearly nebulous as well as orthotropic. The peel, on the other hand, has an aligned cubic crystal fibre structure [7].

Heterogeneous composites are made up of several or even completely separate and functionally separate parts, each of which exists in a number of phases. Typically, this tries to leverage the capabilities of several fibres whilst keeping their desired unique traits in the finished product [8]. Synthetic fabrics such as graphite, glass, and Kevlar have dominated the material processing market since ancient times due to their low operating costs and relatively strong physical properties. Furthermore, as environmental impacts grow, research into the idea of substituting fibreglass with natural fabrics in the creation of polymer composites is expanding. Naturally derived fibres have distinct benefits over their usual artificial equivalents, like polymeric composites. Natural fabrics create fewer hazardous emissions if heated or incinerated at the end of their life due to their low densities, particular strength, and considerable rigidity [9]. Furthermore, polymers are sustainable and biodegradable, strengthening chemicals that really aren't harsh on process instruments, are inexpensive, and the feed is typically widely available. Like man-made fibers, these environmentally friendly products have no influence on the well-being of employees who use them. Furthermore, their incorporation into hybrids reduces the quantity of polymer matrices utilised, providing clear financial and environmental benefits. As a result, the emerging group of materials could be regarded as a replacement for ecologically unfavourable synthetic plastics in a wide range of non-structural industries, including insulation boards, sidewalls, space partitions, interior trim, the automobile sector, computers, even packaged food [10]. Tanzania generates about 30,000 tonnes of sisal fibre annually. Because of their abundance, sisal materials are widely used. Every plant makes 100–200 leaflets, so each leaf generates 120–2000 fibre bundles. Sisal strands might be a viable reinforcing material in composite samples due to their superior physical qualities and availability in most regions of the nation.

The usage of sisal fibres might help manage the aggressive sisal weed, create employment, as well as improve environmentalism. Various research studies have looked into how natural fabrics like jute, cotton, flax, rice husk, and sisal affect laminates or how they enhance the mechanical performance of the resulting polymeric materials [11]. One of the pioneering investigations was to assess the postulated usage of sisal as a viable cellulose material for the fabrication of commercialised composites [12]. During their testing, reduced materials with different mixes of sisal and grain straws combined with 4 % methylene phenoxy close-ally resins outperformed single threads. A mix of 70% sisal and 30% wheat bran nanoparticles demonstrated higher overall mechanical and physical properties for use in fibreboard. In terms of torsional stiffness, the blended mixes outperformed the reference mixes of 100% husks or sisal. Padanattil et al.[13] discovered that the physical performance of a composite material supplemented using banana mixed sisal filaments in epoxy-based hybrids results in an enhancement in enhanced mechanical features.

To the best of the researcher, no public research has been conducted on the mechanical characteristics of hybridised sisal with kenaf fibres utilised in hybrid manufacturing. Therefore, the purpose of this work would have been to create a sisal-kenaf fiber-reinforced polyester composite as just a substitute raw resource for unistructural purposes.

Materials and Methods

2.1 Materials

Alpha Pharmaceutical Manufacturing in Chennai, India supplied unsaturated polyester resin as well as methyl ethyl ketone peroxide. The Wood Plastic Factory in Madurai, India, willingly donated sisal and kenaf threads, which are historically used to make rope as well as cords. All filaments were again properly dried in an oven at 70 °C for 30 minutes to eliminate extra liquid that otherwise might result in poor fibre-matrix bonding. Figure 1 shows the photographic images of reinforcement and matrix materials.

Fig.1. Photographic Images of (a) Sisal; (b) Kenaf and (c) Polyester Matrix

2.2 Composite Fabrications

Manual hand lay-up techniques with minor changes were used to create kenaf-sisal fiber-reinforced biocomposites. A cleaned aluminium plate was employed to make a mould spanning 150 x 150 x 3 mm, which resulted in a composite size of 150 x 150 mm being made. The mould was cleansed with alcohol before applying the mould release agent to the inside areas. The internal parts were again coated with tinfoil to reduce the possibility of adhering to the mould areas and also to create an excellent surface quality. Table 1 summarises the exploratory approach for the quantity of matrix phase as well as reinforcement employed in the polymeric matrix. According to the customer's specifications, unstructured binder and curing agent were combined in a 1: 0.02 weight ratio and carefully agitated. Hand stirring was favoured because it enabled the segregation of identical fibres, which tend to cling together during mixing. As a consequence, the threads were dispersed uniformly, reducing flaws in the composite specimen. The polymer was then combined using mixed threads for 15 minutes to guarantee homogeneous fibre distribution inside the polymer. The substance was then put into moulds and carefully distributed to ensure the same thickness of the finished composite. A clear plastic layer is used to wrap the mould and is instead softly and consistently compressed with a press roller to avoid air trapping throughout manufacturing. A faraway line was employed to adjust the composite's intended width. The barrier kept the male moulded form from rising above a specific level during press, allowing it to be controlled in thickness. The materials were permitted to cure at room temperature for 24 hours at 50 bar compression force before being cut for mechanical characterization.

TABLE 1. WEIGHT FRACTIONS OF FIBERS AND THEIR BLENDING RATIO

Run No	Weight Fraction of Fibers	Blending Ratio I	Blending Ratio II
1	2.5	50/50	0/100
2	5	50/50	25/75
3	7.5	50/50	50/50
4	10	50/50	75/25
5	12.5	50/50	100/0

2.3 Materials Characterizations

Before testing, mixtures for a variety of materials are prepared at ambient temperatures and humidity. Both tensile and compression tests have been performed on general UTM equipment with a strain gauge capacity of 10 kN. The tensile and compressive characteristics were evaluated using ASTM D638-03 as well as ASTM D3410-03 specifications, correspondingly, at loadings of 1.5 mm/min. Flexural characteristic tests were undertaken to use the ASTM D790 in the same UTM. The ISO 179-1:2000 specification was employed to determine the impact strength required to use a Charpy instrument.

Result and Discussion

3.1 Mechanical Properties at Constant Blend Ratio

Figure 2 depicts the mechanical properties of the hybrids at a fixed fibre mix proportion of 50/50 as well as changing fibre content percentages. Bending, tension, and compression behaviours improved by 52.14%, 69.85%, and 33.58% even as hybrid material weight percentage grew between 2.5 and 10% wt, exhibiting peak values of 52.82, 36.50, and 28.25 MPa, correspondingly. There have been substantial changes in the average bending, tension, as well as compression strengths of hybrids generated by various high modulus loading conditions. As fibre content rose to 10% wt, this could be attributed to a rise in the quantity of fibres constituting components that carry loads inside the compounds plus its homogeneous distribution inside the matrices. The measured variables might be attributed to a superior fibre-matrix interaction as a consequence of the uniformly distributed threads as well as the inclusion of sisal fibres inside the mixtures [14]. Furthermore, when the hybrid material weight percentage grew from 10 to 12.5%, the bending, tension, and overall compression strength decreased by 14.63%, 17.07%, and 19.63%, correspondingly. This might be related to lower fibre wetness, which may result in poor crosslink density for both the threads as well as the substrate. This results in a balanced matrix connection and, as a consequence, a greater squeeze [15].

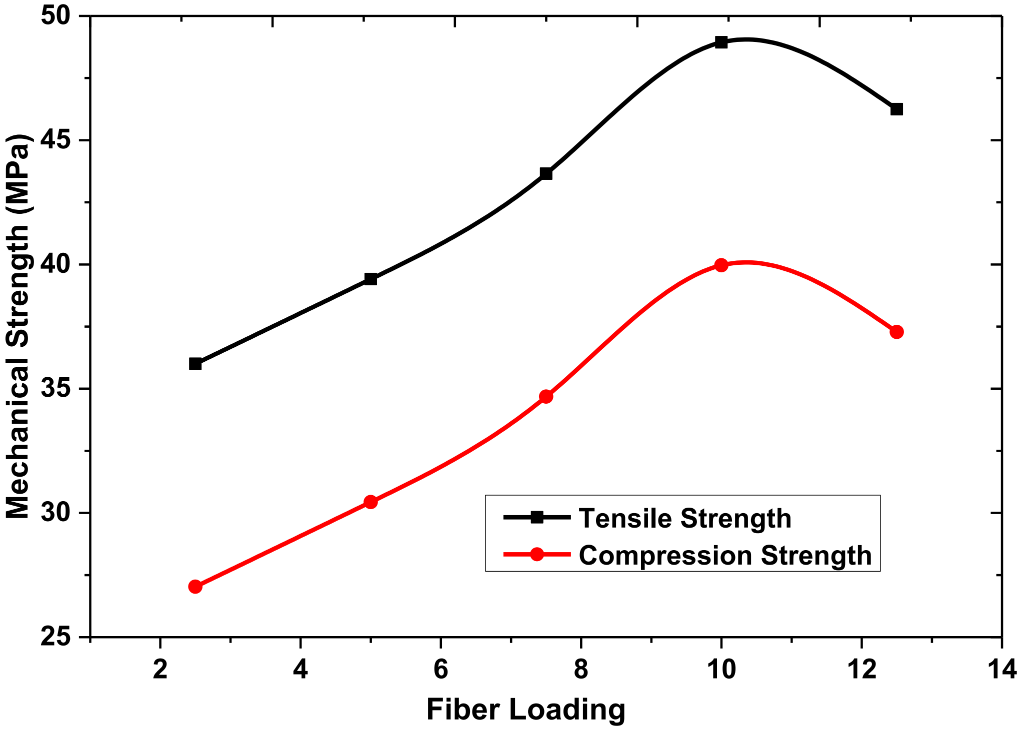

Fig.2. Tensile and Compression Behaviour of Sisal/Kenaf Based Polyester hybrid composites

Figure 3 demonstrates the fracture toughness of mixed composites using various hybrid fibre weight percentages at a fixed fibre blend ratio. The impact energy did not alter significantly when the fibre weight rose from 2.5 to 5 wt%. Furthermore, increasing the fibre weight from 5 to 10% caused a significant gain in impact resistance, with an exceptional standard of 32.52 kJ/m2 at 10%, followed by a decline in impact resistance from 10% to 12.5%. This pattern was similar to prior research, where there would be no difference in impact resistance from 2.5 and 5 wt%, characterised by a quick rise from 5 and 10 wt% as well as a considerable decline at 10 wt% [16]. The behaviour between 2.5 and 5 wt% might well be related to a lattice distortion of a resulting sisal/kenaf biocomposite, wherein different fibre workloads result in fewer transverse threads in the affected area, causing a reduction in crack growth barrier [17]. Furthermore, no changes in the failure modes of the materials were found within this region. At 10% wt, more ragged break areas were found relative to certain other blends with fewer acute cracks. This might explain why higher intensity rates of 10% have been found, as scalloped cracks are said to retain greater impact force. The decrease in impact resistance at 10 and 12.5 wt% could also be responsible for increases in superfast broadband interaction that result in fibre aggregation and, finally, a decrease in fibre load transmission.

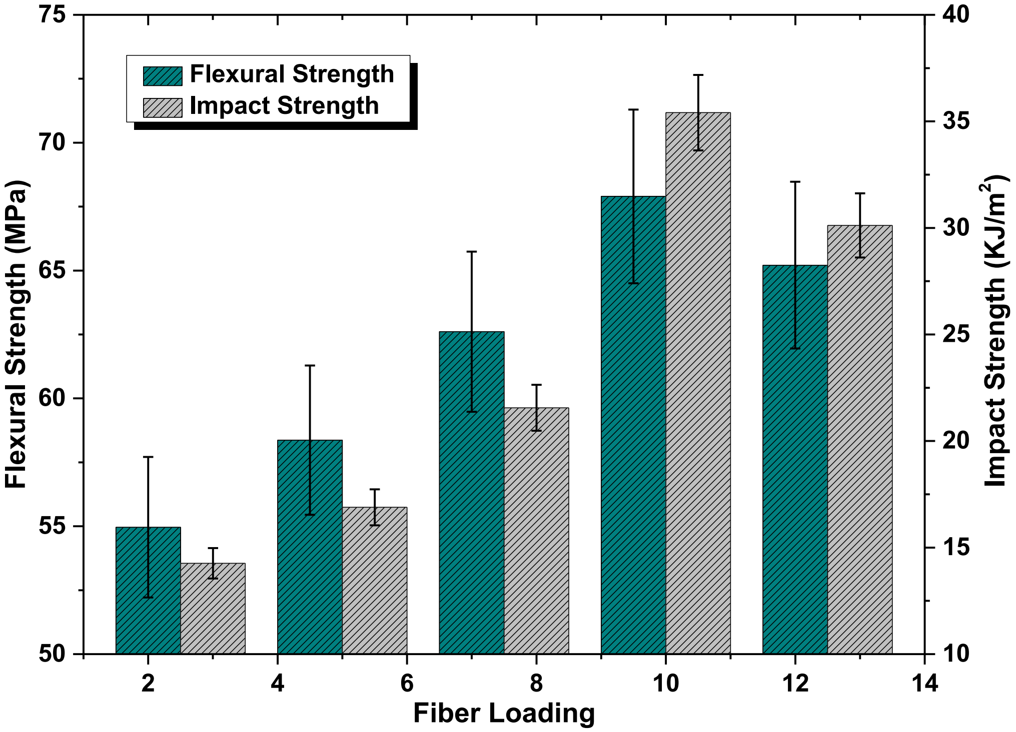

Fig.3. Flexural and Impact Behaviour of Sisal/Kenaf Based Polyester hybrid composites

3.2 Mechanical Properties at Constant Fiber weight

Figure 4 depicts the bending, tension, as well as compression capabilities of hybrid biocomposites with a 10% fixed fibre weight percentage and varying fibre mix proportions. Bending, tension, as well as load bearing capacity rose by 112.14%, 55.48%, and 70.12%, correspondingly, even as the proportion of sisal fibre inside the mix grew from 0 to 75%, yielding maximum values of 45.97, 32.39, and 25.43 MPa at 75/25 sisal/kenaf fibre mix proportions. The bending, tension, as well as compression values of all experimental polymers are found to be markedly different from one another. Past research on jute powdered polyester matrix with a strength property of 18.90 MPa as well as pineapple shell powdered urethane or synthetic polymer hybrids having compressive strengths ranging from 32.56 to 37.14 MPa yielded similar results [18]. It is worthy of note that biocomposite materials have higher mechanical performance than nonbonding kenaf/polyester hybrids. This demonstrates a beneficial homologous recombination impact on kenaf fibres, which may be ascribed to greater fibre dispersion in composite samples compared to entirely natural fibres.

The bending, tension, as well as compression capacities of kenaf/polyester hybrids were significantly lower than those of sisal/polyester hybrids. This pattern may be compounded by

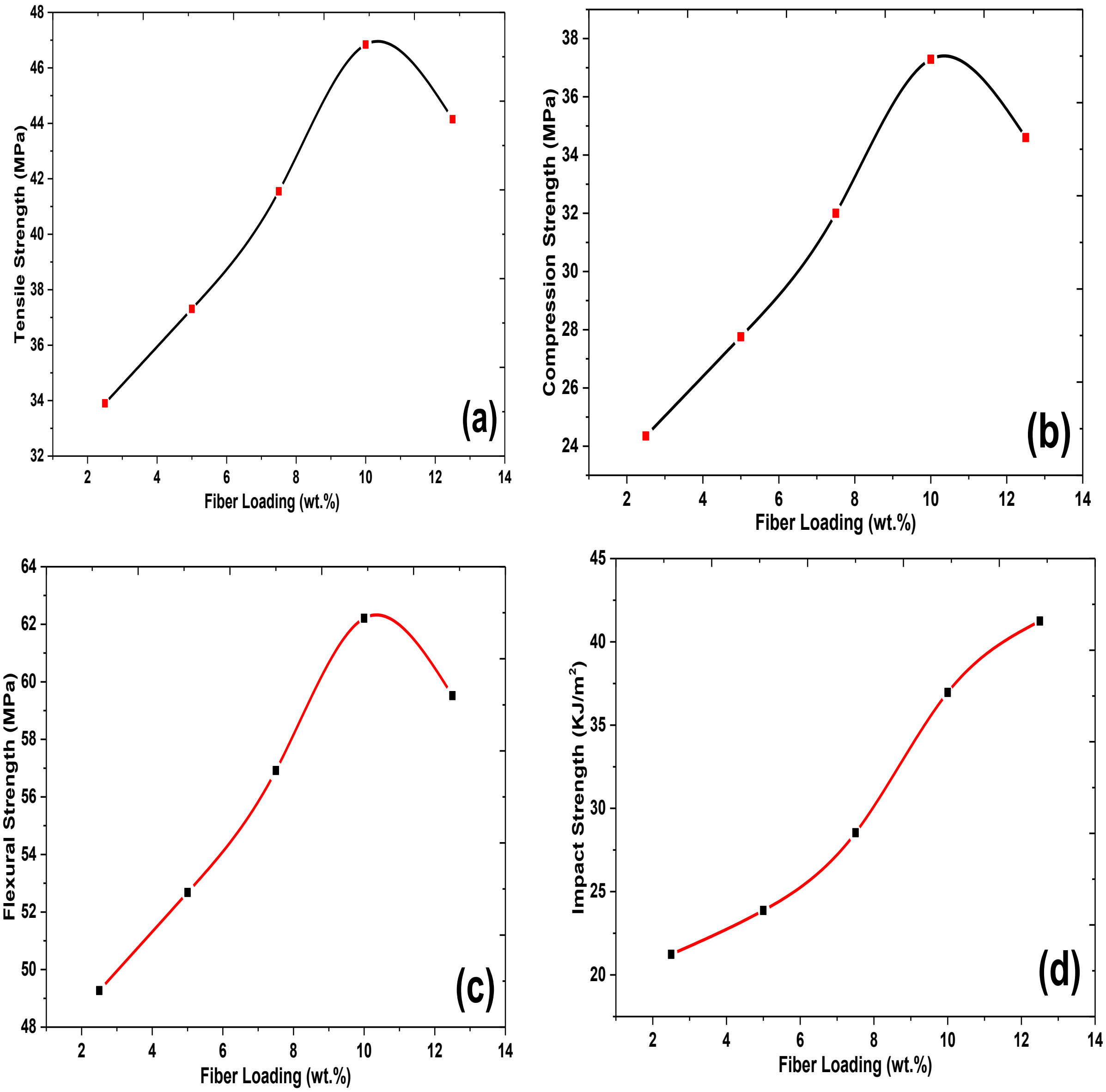

Fig.4. Mechanical Properties of Sisal/Kenaf hybrid composites (a) Tension; (b) Compression; (c) Flexural and (d) Impact

the fact that sisal fibres have stronger tensile characteristics than kenaf fibres, meaning the sisal fibres have a stronger positive impact inside the matrices than kenaf fibres. It was discovered that the length of a sisal was less than a kenaf fibre, implying that the contact angle of a fibre accessible to a substrate is greater in sisal-based hybrids than in kenaf-based hybrids. In sisal fibre blends, this guarantees strong interconnections among reinforcement and the matrix, and also increased stress transmission between reinforcement and lattice. That reflects the pattern seen in this investigation, in which bending, tension, and load bearing capacity rose with increasing sisal fibre content inside the hybridization between 0% and 75% as synergy was developed. Moreover, when the amount of sisal fibre packing inside the hybridization grew from 65 to 90 %, the bending, tension, as well as compression strength decreased by 37.25 %, 16.58 %, as well as 6.25 %, correspondingly. The outcomes are in line with earlier findings and may be ascribed to fabric aggregation produced by greater sisal fibre content, which results in a reduction in load transmission among sisal composite structures [19].

Figure 4 also describes the effect of altering the amount of sisal/kenaf thread in the combination at a fixed combination fibre volume fraction of 10 % wt on laminate impact resistance. The fracture toughness of a composite material increased consistently from 0 to 100% by 48.72%, with the greatest benefit of 34.89 kJ/m2 at a sisal/kenaf proportion of 100 % with 0 %. This tendency is consistent with prior research that found sisal/polymer hybrids to have good impact characteristics. The permeability of sisal and its large microfibril inclination may explain the progressive rise in impact resistance with increasing sisal filler content. As a result, impact energy rose as that of the sisal portion of a hybridization rose, which might be attributed to the flexible microhardness related to sisal fibres' steep helix inclination and also its pore structure. As a result, hybridization had a negative impact on compound impact resistance because sisal-based combinations had higher fracture toughness than kenaf-based hybrids [20].

Conclusion

The current study focused on the effects of using sisal/kenaf fabric blends to strengthen hybrid composites. Once at a sisal to kenaf mix ratio of 65/35, polyester hybridization composite manufactured at a continuous filament weight percentage of 10% achieved excellent bending, tension, as well as compression strength. The impact energy of a fibre mix rose even as the sisal component improved. Throughout this work, the spalling for sisal/kenaf fiber-reinforced polymer composite included fibre pull-outs as well as filament breakage. More research should be conducted to investigate the influence of chemical modification of a filament on the characteristics of a strengthened biocomposite.

REFERENCES

1. Sahari, J.; Sapuan, S.M.; Zainudin, E.S.; Maleque, M.A. Mechanical and Thermal Properties of Environmentally Friendly Composites Derived from Sugar Palm Tree. Mater. Des. 2013, 49, 285–289, doi:10.1016/j.matdes.2013.01.048.
2. Saiful Islam, M.; Hamdan, S.; Jusoh, I.; Rezaur Rahman, M.; Ahmed, A.S. The Effect of Alkali Pretreatment on Mechanical and Morphological Properties of Tropical Wood Polymer Composites. Mater. Des. 2012, 33, 419–424, doi:10.1016/j.matdes.2011.04.044.
3. Kumar, M.A. Thermal Analysis of Epoxy / Polyester Blend Filled With Thermal Analysis of Epoxy / Polyester Blend Filled With Montmorillonite (Mmt) Clay –. 2016, 4, 123–132.
4. Akil, H.M.; Omar, M.F.; Mazuki, A.A.M.; Safiee, S.; Ishak, Z.A.M.; Bakar, A.A. Kenaf Fiber Reinforced Composites : A Review. Mater. Des. 2011, 32, 4107–4121, doi:10.1016/j.matdes.2011.04.008.
5. Yahaya, R.; Sapuan, S.M.; Jawaid, M.; Leman, Z.; Zainudin, E.S. Effect of Fibre Orientations on the Mechanical Properties of Kenaf- Aramid Hybrid Composites for Spall-Liner Application. Def. Technol. 2015, doi:10.1016/j.dt.2015.08.005.
6. Saba, N.; Paridah, M.T.; Jawaid, M. Mechanical Properties of Kenaf Fibre Reinforced Polymer Composite : A Review. Constr. Build. Mater. 2015, 76, 87–96, doi:10.1016/j.conbuildmat.2014.11.043.
7. Invest, E.; Ion, I.; Flexural, O.F.; Charact, M.; Ics, E.; Behavior, W.; Hybrid, O.F.; Es, C.; Areca, W.I.T.H. EVALUATION OF MECHANICAL PROPERTIES OF KENAF BASED HYBRID COMPOSITE FOR AUTOMOTIVE COMPONENTS EVALUATION OF MECHANICAL PROPERTIES OF KENAF BASED.
8. Aji, I.S.; Sapuan, S.M.; Zainudin, E.S.; Abdan, K. KENAF FIBRES AS REINFORCEMENT FOR POLYMERIC COMPOSITES : A REVIEW. 2009, 4, 239–248.
9. Coefficient, F.; Strength, I.; Fiber, R.S.; Hybrid, E. Journal of Composite Materials. 2010, doi:10.1177/0021998310371551.

10. Alavudeen, A.; Rajini, N.; Karthikeyan, S.; Thiruchitrambalam, M.; Venkateshwaren, N. Mechanical Properties of Banana/Kenaf Fiber-Reinforced Hybrid Polyester Composites: Effect of Woven Fabric and Random Orientation. Mater. Des. 2015, 66, 246–257, doi:10.1016/j.matdes.2014.10.067.
11. Sgriccia, N.; Hawley, M.C.; Misra, M. Characterization of Natural Fiber Surfaces and Natural Fiber Composites. Compos. Part A Appl. Sci. Manuf. 2008, 39, 1632–1637, doi:10.1016/j.compositesa.2008.07.007.
12. Taj, S.; Munawar, M.A. Natural Fiber-Reinforced Polymer Composites NATURAL FIBER-REINFORCED POLYMER COMPOSITES. 2014.
13. Padanattil, A.; Karingamanna, J.; Mini, K.M. Novel Hybrid Composites Based on Glass and Sisal Fiber for Retrofitting of Reinforced Concrete Structures. Constr. Build. Mater. 2017, 133, 146–153, doi:10.1016/j.conbuildmat.2016.12.045.
14. Aslan, M.; Tufan, M.; Küçükömeroğlu, T. Tribological and Mechanical Performance of Sisal-Filled Waste Carbon and Glass Fibre Hybrid Composites. Compos. Part B 2018, doi:10.1016/j.compositesb.2017.12.039.
15. Panzera, H.; Christoforo, L.; Mano, V.; Carlos, J.; Rubio, C.; Scarpa, F. Hybrid Composites Based on Sisal Fibers and Silica Nanoparticles. 2016, 1–11, doi:10.1002/pc.
16. Yahaya, R.; Sapuan, S.M.; Jawaid, M.; Leman, Z.; Zainudin, E.S. Effect of Layering Sequence and Chemical Treatment on the Mechanical Properties of Woven Kenaf-Aramid Hybrid Laminated Composites. J. Mater. 2014, doi:10.1016/j.matdes.2014.11.024.
17. Naveen, J.; Jawaid, M.; Amuthakkannan, P.; Chandrasekar, M. 21 - Mechanical and Physical Properties of Sisal and Hybrid Sisal Fiber-Reinforced Polymer Composites; Elsevier Ltd, 2019; ISBN 9780081022924.
18. Polyester-based, F.U. Chemical Resistance Studies of Silk / Sisal. 2008, 1–4, doi:10.1177/0731684408097770.
19. Karthik, N. Mechanical & Thermal Properties of Epoxy Based Hybrid Composites Reinforced with Sisal / Glass Fibres.
20. Cisneros-lópez, E.O.; González-lópez, M.E.; Pérez-fonseca, A.A.; González-núñez, R.; Rodrigue, D.; Robledo-ortíz, J.R.; González-lópez, M.E.; Pérez-fonseca, A.A. Effect of Fiber Content and Surface Treatment on the Mechanical Properties of Natural Fiber Composites Produced by Rotomolding. 2016, 6440, doi:10.1080/09276440.2016.1184556.