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Investigate the Effectiveness of NaOH Treatment on the Mechanical and Moisture absorption behaviour of Kapok fibre Based natural Composites

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ABSTRACT

The physical and chemical properties of a higher-intensity polypropylene matrix material bolstered to kapok fibre with regard to fibre content have been explored. An acidic environment has been used to enhance the stability of a kapok fibre. The polymeric specimens were taken using five distinct kapok fibre workloads with a fibre length of 50 mm. A compression mould with horizontal fibre orientations was used to create the element. Tension, toughness, as well as intensity tests were used to examine the impact of fibre content. Structural rigidity was 25 percent higher with 55 percent fibre concentration than without, and elastic modulus was 36 percent higher. During this time, the toughness as well as saturation of the biodegradable polymers have been discovered to be very comparable, with slight grows from 20 wt% to 42 wt% kapok loading compared to the control layer's 0 wt% kapok. As per the observations, the chemical treatment of a polymeric matrix had a massive impact on material properties.

Keywords: NaOH Treatment; Kapok Fiber; Natural composites; Mechanical Properties; Moisture absorption.

INTRODUCTION

Scientists, notably in the fields of robotics, transportation, packaging, carpentry, and building, have successfully proved a keen interest in the development of disposable fibre polymeric composite compounds as an alternative to conventional resources. The abundant convenience of lignocellulosic biomass is indeed the driving force of an increasing focus on green technology [1]. Climate change as well as the depletion of non-renewable resources have sparked demand for biological fabric blends as a replacement. Natural materials present in soil could be used to improve disposable polymers. Biocomposites provide diverse natural benefits, including being recyclable and recyclable, in addition to their high hardness or tribological. The purpose of this study is to assess the innovative viability of the project depending on its ecological impact [2]. These are also light, cheap, and will have excellent mechanical properties. Today, a broad range of natural materials are widely used. Coir, jute, wood, cypress mulch, cotton, rattan, hemp, pineapple, or palm oil mill threads seem to be just a few of the naturally fibered composites being researched for possible industrial use [3].

Throughout this study, kapok fibre was employed as a reinforcement material, while polypropylene was used as the substrate. Natural threads' advantages in commerce include their low weight, being inexpensive, nontoxicity, biodegradability, and relatively high elasticity. Such qualities make organic fiber-reinforced polymers excellent for use in the automotive and aerospace sectors. Automobiles should be built in such a way that at least 85% of the vehicle's speed can be recycled or remanufactured. Fibre strength is an important aspect for potential industrial purposes [4]. Natural materials with good strength capabilities, such as jute, linen, worsted wool, wood, or bamboo, could be used to make fiber-reinforced polymers. Kapok is appreciated for its excellent mechanical durability, tolerance to salt, and continuous fibre duration. It is established that kapok fibre may be used as a reinforcement material both with thermoplastics and malleable plastics. In the Netherlands, kapok bananas are grown economically as a source of revenue [5]. Mercedes-Benz automobiles were safeguarded by using Kapok fiber-reinforced plastics. Kapok fibres would have to be water repellent as well as other external elements like temperature or rock contact in order to fulfil the stringent requirements of transportation. For effective and precise commercialization, understanding of the precise physiochemical properties of kapok fibres as well as the construction relationship is required. Natural fabrics really aren't suitable for hybrids due to their moisture content or poor interfacial contact with the polymeric matrix [6].

Natural materials still want to supersede traditional strands in elevated situations. Organic fiber-reinforced plastics are often used for trunk lids, chairs, as well as other exterior screens. Fiber reinforced surface morphology has become progressively necessary as a result of its immense commercial possibilities. Additional research was conducted to advance fibre bonding and reduce moisture levels, which are two important topics of work in the domain of fibre enhancement [7]. The usage of kapok fibre as just a redistributive in textiles and made up of lightweight items is extremely appealing. As little more than a consequence of using Kapok, organic samples obtained from production can reduce pollution, waste disposal challenges, as well as other climate change. Natural fabrics have significant limitations due to their excessive water penetration and limited reactivity with diverse proteoglycans. Through the use of proper care, like alkalization or warming, the surfaces of natural materials can be changed to increase adherence between the wet plant fibres as well as the dry matrix material [8,9]. As per the results, alkali behaviour improves the brittle hardness and elasticity of materials. Investigators will employ alkaline-treated kapok fibre from the goals variety as reinforcements to understand as much about the material properties of polypropylene mixtures as possible.

The key aims of this experiment were the alkali pre-treatment of kapok surfaces and fibre removal. The polymeric composite's strain, toughness, or unit weight were all tested. Trees are the source of cellulose fibers. Hardwood, agricultural runoff, native organisms, or grass are examples of lignocellulosic biomass substances. waste organic fibres' content, properties, and makes a lot of it suitable for a wide range of uses, including polymers, fabrics, or old newspapers. Apart from it now, natural fibres may be used to create everything from energy to pharmaceuticals, proteins, and nutrition [10]. Because they are all robust cellulose fabrics, a huge spectrum of threads, including flaxseed to empty fruit thread, are used in the fabric and package sectors, which also reduces building as well as the newspaper producing business. Such strands are classed as tough owing to their high tensile properties and little distortion after breakage. Many efforts by engineering graduates to combine natural materials into polymers have failed. As per the report's results, these have high fracture toughness as well as intense magnetic, toxicological, thermal, or acoustical thermodynamic stability. Due to the obvious increase in interest in cleaner production, hemicelluloses were employed as a low-cost, reusable, yet economically advantageous reinforcing phase [11]. Natural fabrics are an appealing alternative to synthetic or petroleum fibres because of their relatively low cost, lighter weight, or lower intensity. Because it is simultaneously inexpensive and plentiful, kapok is a potential environmental fibre structural member. Fibers derived from the pseudo-stem of a banana tree, often known as natural fibres or kapok, possess moderate ductility. Kapok and other flexible vegetation are prevalent in tropical locations and can be produced as a commodity. Kapok fibre is now a result of crop cultivation. As a result, there really is no added cost in obtaining and manufacturing kapok fibre. Lately, curiosity in kapok fiber-reinforced plastics has grown because of the innovative usage of kapok in fortifications of roadside autos. Kapok fibre is believed to offer a high potency proportion with a modulus of elasticity equivalent to fibreglass. When constructing natural fibre with kapok fibre, a variety of aspects should be addressed.

Polymers can be degraded by environmental elements such as moisture, sunlight, or microorganisms. That is a big worry. The poor susceptibility of fibres to water uptake could have a harmful influence on efficient load transfer from the polymer to a thread. Because understanding the long-term effects of new fibre reinforced moisture content and the endurance of composite ageing in moisture is critical, this phenomenon must be thoroughly investigated [12]. Since natural fabrics are hydrophobic, the interparticle adhesion to a polymer matrix is restricted, and their promise as reinforcement materials is frequently restricted; synthesis methods are being investigated to improve the fibre interaction. Wettability could be dramatically decreased by chemical treatment of textiles [13,14]. Fibers, for instance, could be coated using alkaline or even other caustic substances to reduce the absorption of moisture. Alkali-treated materials exhibit higher rigidity, strength, or variable elastic strength, showing that their interface binding power or adherence of the matrix and the fibre has increased. Fiber reinforced contaminants like phenol as well as tannin were hypothesised to inhibit fibre adhesion to a substrate throughout the fabrication of composites.

Natural materials are generally prescribed to increase the interfacial bonding between polymers as well as the fibers. The simplest way is to use an alkaline solution to improve fibre bonding. However, it diminishes forces exerted throughout pre-treatment, which would be a drawback. The solitary kapok fibre's water uptake tests are unknown. If we know how fibres retain water, we could employ them less efficiently in synthetic structures. Therefore, our goal in this research is to thoroughly investigate kapok fibre to determine how chemical modification affects its water process of integration.

MATERIALS AND METHODS

2.1 Materials

In this study, kapok was created using a novel separation approach. Fibers are removed by placing the kapok in an AFM as well as spinning it. Rather than smashing the kapok to eliminate the wax coating, this device uses knives to accomplish the task. Ozonation is a biochemical procedure wherein fibres are immersed in a high proportion of sodium hydroxide aqueous solution for an extended period of time to generate considerable swell with associated changes in lattice, dimensions, and material performance at a specific temperature. Following separation, the threads were alkali treated to change their surface morphology. The fibres are then immersed in a water tank containing a 5% alkali solution for four hours at room temperature. The threads are then sprayed multiple times in purified water prior to curing at room temperature for 24 hours. Chemical treatment can improve the mechanical properties of the fiber, remove contaminants, stabilise aids, cure the surface structure, and promote adherence between wet kapok and dry polyethylene. Figure 1 Demonstrates the kapok fiber extraction from kapok tree. Table 1 shows the Parameters and their levels of Kapok composites.

Fig.1. Kapok Fibre extraction from Kapok tree

TABLE 1. PARAMETER AND COMBINATIONS OF NATURAL COMPOSITES

Sl.No	Weight Ratio of Kapok (wt.%)	Weight ratio of Resin (wt.%)
1	10	90
2	20	80
3	30	70
4	40	60
5	50	50

2.2 Fabrication of Composites

Compression formwork was utilised to generate a composite layer from numerous kapok/PE hybrids made by hand combining. The goal of higher-intensity polyethylene would be to create items with better forms of attack. The mould is first wiped using wax to guarantee that specimens may be readily retrieved from the mould following press. The initial step when producing composites is to place the kapok and PE combination in a mould to ensure that the filaments are all orientated toward the same direction. After warming to the same ambient, this material was then warmed to 170°C for 10 minutes, then 2.9 MPa pressure for 10 minutes to form this 3 mm thick layer.

2.3 Mechanical Characterization

Tension characteristics of polymeric matrices and lightweight materials are measured using the ASTM D-3039 Specification. The components were assessed using a UTM configuration with a constant flow performance test rate of 1 minute per mm with dimensions of 140 mm long, 13 mm wide, and 3 mm thick. The sample was then placed in the handles of the diagnostic tools, and mechanical pressure was exerted till it burst. The thickness of the kapok/PE combination was determined using a portable computing medium. Hardness can be calculated on the basis of a product's bending in the presence of an external stimulus. The toughness of the kapok/PE combination was measured using an automated Shore grade "D" style folder in conformity with ASTM D1957. Researchers were capable of determining the toughness of a specimen by determining the depth of the depression with a dial gauge. Conduct the toughness examination at least 12 mm from one of the pattern's edges to prevent biassing the findings.

RESULT AND DISCUSSIONS

Figure 2 displays the lengthwise material strength of Kapok/PE samples under varying Kapok workloads. Every bar on the chart, like a typical error margin, shows that the derived value should be within an appropriate limit. Kapok feeding does have a considerable impact on the conduct of the composite. A mechanical property of 67.81 MPa required 50 percent of the Kapok load. When compared to conventional polyethylene and polypropylene, fibre increases of 10% and 40% increased tensile strength by 120 and 180 %, respectively. The rate of advancement is constant when compared to certain other biocomposites. Other researchers' studies employing different genotypes revealed poorer physical ability than any of those obtained herein [15]. In the longitudinal direction, the material evaluated had strength properties of 42 MPa. This article's higher tensile toughness could be linked to the properties of kapok as well as the impact of alkalization on its own surfaces. In other respects, it's more successful whenever the kapok is orthogonal to a tension plane. It's because increased fibre packing increases the composite's tensile strength.

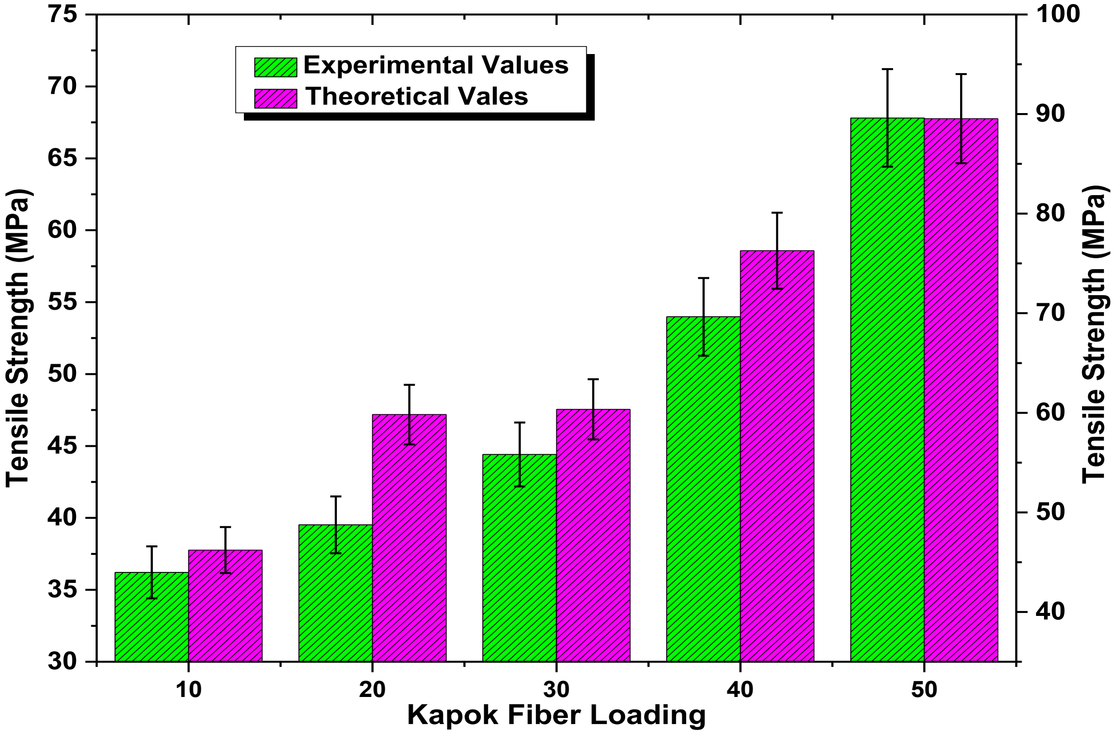

Fig.2. Tensile Behaviour of Experimental and Theoretical values of Kapok based natural composites

Because the matrices are responsible for transmitting pressure to the filaments, increased fibre packing provides for better pressure absorption than just a smaller fibre loading. Throughout the material's manufacturing, this was combined with such small particles of polypropylene, resulting in hybrids. As a consequence, the amount of biocomposite adhesion is increased [16]. The high fibre adhesive allows pressure transmission from the sample to the strands, improving the mechanical properties of the composite. The stress properties of the product will obviously be lowered because of the greater strength properties caused by fibre loading. Moreover, the findings of this test revealed that adding insoluble fibre improves stress features [17]. Additional acid threads will thus improve overall straining characteristics of the composite, as well as the kapok with PE's high adhesive have developed. That's because the PE is in a precipitated state. The mechanical hardness in the lateral direction was calculated using the rule of combinations, as shown in Equation (1).

$$Stress = Y_m Y_m + Y_f Y_f \qquad (1)$$

A comparison of real and hypothetical analysis indicated that as kapok concentration increases, so does tension performance. However, the test results were less than planned. Strands may have been misplaced, or the composite may have been manufactured incorrectly. The longitudinally elastic modulus of a kapok/PE composite is depicted in Figure 5 at different kapok stacking situations. Although at 50 wt%, elasticity improves with kapok weight, as indicated in the figure. The elastic modulus of simple PE increased by 328 %, whereas the elastic modulus of fibre decreased by 62 %. The enhanced elastic modulus of a combination was discovered to be due to improved adherence between fibre matrix and substrate [18]. Figure 3 compares theoretical and actual elastic modulus findings for kapok weight. The following formula could be used to calculate the moduli:

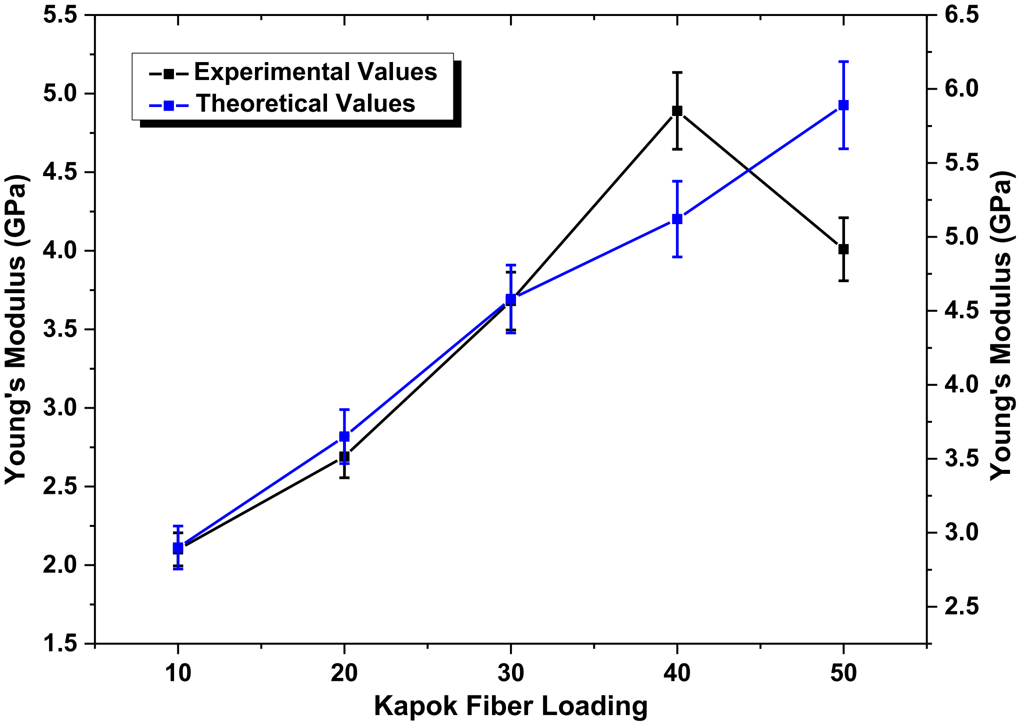

Fig.3. Young's Modulus of Experimental and Theoretical values of Kapok based natural composites

The Shore-D as well as density (g/cm^3) profiles for longitudinally kapok/PE hybrids depending on kapok stacking are shown in Figure 4. Durability as well as density all improve as kapok content increases. Once 10 wt.% fabric is introduced to simple PE, the toughness as well as density increase by 0.63 % as well as 5.21 %, respectively. The consequence of increasing kapok weight by a percentage of up to 65 wt.% is equivalent to increasing kapok dosage by a ratio of 50 wt.%. Different biocomposites are also becoming more attractive. The hardness and the composite's strength are proportional to its barrier properties. The densities of a combination have grown as the fibre content has risen because of the close packing of a thread. Raising overall kapok load capacity in a kapok/PE hybrid enhanced its susceptibility to puncture, resulting in a rise in hybrid densities [19].

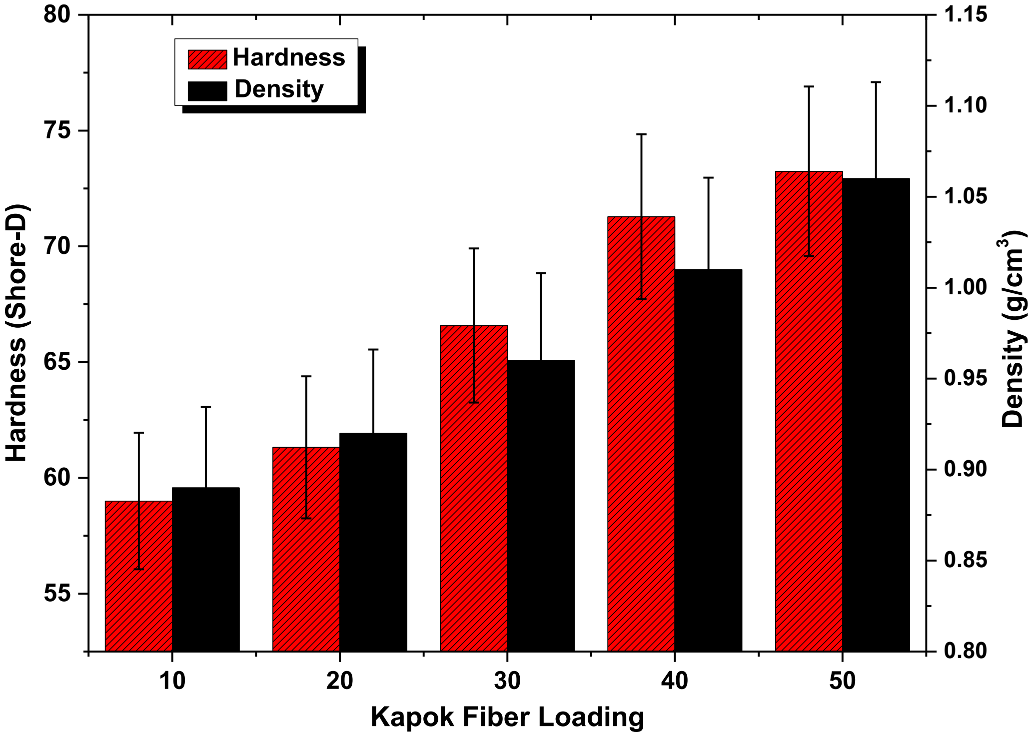

Fig.4. Shore D and Density values of Kapok based natural composites

Conclusion

As demonstrated by this research, Kapok fibres processed by caustic have had an impact on the improvement of hybrid strength, and fibre packing impacts the elastic properties of an impacting polypropylene hybrid. The 50 wt.% Kapok/50 wt.% PE hybrids had the greatest material characteristics of all the other constituent proportions, with a tensile property of 67.81 MPa, with elastic modulus increasing to kapok loading unless at 50 wt.%, as well as a toughness of 73.24 Shore-D, correspondingly. Durability as well as density both rise as kapok weight rises. If kapok loading is extended by up to 50%, the impact is comparable to increasing kapok weight by 30%. Irregular filament dispersion was already discovered to have an effect on the mechanical properties of kapok-polypropylene compounds.

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