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Physico-Mechanical Behaviors of Chemically Treated Natural Fibers Reinforced Hybrid Polypropylene Composites

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Haydar Uz Zaman[1,*]

[1] Department of Physics, National University of Bangladesh and Institute of Radiation and Polymer Technology, Bangladesh Atomic Energy Commission, P.O. Box-3787, Savar, Dhaka, Bangladesh

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ABSTRACT

The goal of current research is to replace synthetic materials with natural, biodegradable, and renewable ones. Natural fiber composites are extensively studied due to their unique properties and environmental benefits. These fibers are easily available, easy to handle, and biodegradable. Reinforcing polymers with natural fibers enhances mechanical properties, potentially balancing stiffness, strength, and ductility in hybrid composites. This study assessed the mechanical characteristics of polypropylene reinforced with chopped banana fiber and coconut husk. Investigations were also conducted into the effects of fiber chemical treatment, content, and ratio on mechanical properties. In Bangladesh, two fibers that are commonly available are coconut husk and banana. Raw coconut husk and banana fiber were chemically treated with 5% sodium lauryl sulfate to improve their adhesion with polypropylene. Hot pressing was employed to manufacture the composite using fibers that had been treated with sodium lauryl sulfate (SLS) as well as untreated fibers. The fiber loading was adjusted to be 5, 10, 15, and 20 wt%, while the ratios of coconut husk to banana fibers were modified to be 15/5, 10/10, and 5/15. After that, tests for tensile, flexural, hardness, and water absorption were performed on the created composites. All mechanical parameters increased with increased fiber loading, except for tensile strength. The characteristics of the generated composites were found to be better than those of the polypropylene matrix. The mechanical properties of composites including coconut husk and banana fiber at the 5/15 ratio were superior to those of composites comprising those fibers at the 10/10 or 15/5 ratios. Specifically, the 5/15 ratio composites improved tensile strength, tensile modulus, flexural strength, flexural modulus, and hardness by 11%, 6%, 12%, 24%, and 2%, respectively, compared to the 10/10 ratio composites. Treated fiber composites using SLS-treated coconut husk and banana fiber at the 5/15 ratio showed enhanced mechanical properties compared to untreated composites. These treated composites improved tensile strength, tensile modulus, flexural strength, flexural modulus, and hardness by 17%, 5%, 4%, 1%, and 2%, respectively, over untreated composites. Thus, SLS-treated fiber-reinforced hybrid composites exhibited superior characteristics compared to their untreated counterparts.

* *Corresponding author.*
E-mail address: haydarzaman07@gmail.com (Haydar Uz Zaman)

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1. Introduction

The growing popularity of lignocellulosic materials can be attributed to a number of causes, including global warming, increased energy consumption, depleting petroleum reserves, and high raw material costs. Examples of lignocellulosic materials include agricultural waste, grasses, timber, water plants, and plant waste fibers such as banana, sisal, jute, hemp, coir, pineapple leaf fiber, kenaf, flax, and others. Natural fibers are currently used primarily in the automotive, packaging, building and construction, railway coach interiors, storage devices, and partition wall cabinets, among other industries, because of their many advantageous qualities, which include lightweight (low density), cheaper source, good specific strength and modulus, biodegradability, high degree of flexibility, non-carcinogenic, and absence of health hazards. Furthermore, the main reason that enterprises choose to use natural fibers as raw materials is that they are widely available and come in a wide variety of forms. Researchers have discovered that engineers and scientists are working very hard to employ natural fibers in applications that bring value [1, 2]. Nowadays, natural fibers and agricultural biomass are commonly used as fillers and reinforcement in composite materials. The material's exceptional electrical resistance, robust fracture resistance, and thermal and acoustic insulation properties were the causes of this.

New forms of composite materials have been developed as a result of the need for modern composite materials to have a number of conflicting properties. These materials, which are referred to as hybrid composite materials, combine layers of reinforcing fibers that are composed of two or more different kinds. The most widely used composite materials to date are polymer hybrid ones. The behavior of hybrid composites is caused by the numerous components, where there is a balance between the inherent advantages and disadvantages. Additionally, by using a hybrid composite that includes different types of fiber, the advantages of one type of fiber could compensate for the drawbacks of another. This may facilitate the combination of performance and cost in composite materials. The main factors that define the properties of a hybrid composite are its fiber content, fiber length, orientation, degree of fiber interweaving, fiber-to-matrix bonding, fiber arrangement, and fiber failure strain [1].

Bananas and coconut husk fiber (coir), which are both inexpensive, readily available, and good for the environment, seem to be the best natural fiber materials overall in Bangladesh. Banana and coconut husk fiber are waste materials from the agriculture industry that have the potential to take the place of synthetic fibers. Agricultural waste items like banana fiber and coconut husk have the potential to replace synthetic fibers in the future. The coir husk contains thick, coarse, and durable natural fiber known as coir fiber. Coir fiber's biodegradable properties mean that it has a minimal environmental impact [2, 3]. In short fiber-reinforced composites, its high failure strain enhance the compatibility of the fiber and matrix under strain. Coir fibers, like those of many other naturally occurring fibers, are made up of 36–43% cellulose, 15.17% hemicellulose, and 32.25% lignin [4]. It also has a higher lignin concentration than other natural fibers, which helps it to be more weather resistant and absorb water less deeply than other natural fibers. Coir fiber has the unusual ability to be stretched over its elastic limit without rupturing because of the helical structure of the micro-fibrils [5]. Banana fiber is a highly sought-after option for a robust natural fiber. Banana fiber is now the waste product of banana farming. Bangladesh, India, Thailand, China, and other nations are the primary locations of the banana plant, Musa sepientum. The pseudostem of the banana plant produces banana fiber, which is a type of stem fiber. Plant remnants that remain after the fruit ripens make banana fiber easily obtainable. Banana fiber can be purchased for industrial purposes without incurring any additional fees. Apart from its numerous benefits, banana fiber is relatively strong when compared to other natural fibers. In addition, it produces fast, has a minimal ecological load, and is easy to regrow after cutting. Bananas include lignocellulosic components such as cellulose (71.08%), hemicellulose (12.61%), and lignin (7.67%) [6]. Acetyl bonds, which are ether connections between the hydroxyl and carbonyl groups, enable the glucose residues that makeup cellulose to be joined [7]. Products derived from bananas were widely utilized all over the world, especially as sandbags on battlefields and for hydraulic dams. These products included rope, shopping bags, gunny bags, matting, the backing for tufted carpets, and low-cost floor coverings.

Bananas and coir, although possessing many beneficial characteristics, are not very moisture resistant, have low thermal stability, and have poor dimensional stability. To efficiently use natural fibers in composite materials, they need to be chemically treated to reduce their hydrophilicity and increase their thermal stability. Frederick *et al.* (2004) claim that coir fiber outlasts other natural fibers in terms of durability. This resulted from the coir fiber's high lignin concentration [8]. Lignin is the natural fiber component with the least potential to absorb water. Natural fibers' hydrophilic nature may have a detrimental effect on how well stress is transferred from the matrix to the fiber [9-11]. So, in order to produce a high-performing biocomposite material, chemical surface modifications of natural fibers are needed, including cyanoethylation, acetylation, methylation, permanganate treatment, and grafting of acrylonitrile monomer [12-14]. One of the most widely used and reasonably priced methods to improve the interfacial interaction between fiber and resin is sodium lauryl sulfate treatment [15]. The partial elimination of surface contaminants and fiber components like lignin, pectin, waxy substance, and hemicellulose brought about by the sodium lauryl sulfate treatment enhances the interfacial adhesion between the fiber and resin.

Polypropylene (PP) is one of the most widely used polymers nowadays. It may be found in many different items, such as textiles, stationery, lab equipment, loudspeakers, computer parts, and polymer banknotes. It is also utilized in packaging and labeling. For many applications, it is the best choice because of its unique combination of features. Great flexural strength, robust impact strength, low coefficient of friction, and exceptional fatigue resistance are just a few of the mechanical properties that make polypropylene a perfect choice for the current study. Not only that, but it is an extremely affordable material with good resistance to moisture and electricity and strong chemical resistance to a wide range of bases and acids [16-20].

This study's main objective is to create hybrid polypropylene composites reinforced with fibers from bananas and coconut husks and evaluate how the ratio and content of the fibers affect the composites' mechanical properties. It has also been demonstrated how certain mechanical properties are affected when banana fiber and coconut husk are treated with sodium lauryl sulfate.

2. Methodology

2.1 Ingredients

Fiber can be extracted using one of three techniques: mechanical, chemical, or hand. Out of all of them, mechanical extraction works best for getting fiber in an economical and environmentally responsible way. A mechanical procedure was used to retrieve the fibers. For this investigation, fiber from bananas and coconut husks were collected from a neighboring field. Banana fiber was taken out of the pseudostem sheath of the plant, while coir fiber was obtained from the husk of the coconut fruit. After extraction, there was still moisture in the fibers. Therefore, fibers were dried after extraction. Commercial-grade polypropylene and sodium lauryl sulfate were bought from the local market. The PP was white in color, granular in texture, and had a melting point of 160°C. In this work, the chemical sodium lauryl sulfate (E. Mark, India Ltd.) was used to alter the fiber from coconut husks and bananas.

2.2 Preparations
2.2.1 Natural fiber treatment with sodium lauryl sulfate

Sodium lauryl sulfate was applied to coconut husk and banana fiber to increase their matrix compatibility. Both times, the identical procedure was used. A 5% sodium lauryl sulfate treatment was applied to the fibers. To make sure all of the fibers were submerged, the dried extracted fiber was first completely submerged in the solution and agitated. After that, the beaker holding the fiber solution was heated to 70°C for around 2.5 hours. Lastly, the fibers were cleaned using tap and distilled water. To ensure total drying, the water-containing fibers were put in the oven.

2.2.2 Preparation of a composite

The compression molding technique was utilized to create composites using a 120 mm × 120 mm x 3 mm aluminum die. A hydraulic hot press machine with a 35 kN maximum load capacity and a 300°C maximum temperature was employed. The ratio of coconut husk to banana fiber was 10:1, and the fiber loading was adjusted between 0 and 20 wt%. Subsequent composites with a 10 weight percent (wt%) fiber loading were created using coconut husk-to-banana fiber ratios of 15/5 and 5/15. Additionally, a 10% fiber loading and a 10/10 ratio of banana and coconut husk fibers were used to generate a fiber composite treated with sodium lauryl sulfate. Firstly, the fibers were divided into segments of between 3 and 5 mm. Subsequently, the needed amount of PP and fiber was measured using a balance. Before each composite was created, the fibers and polypropylene were dried for 20 minutes at 80°C in an oven to allow for the removal of moisture. The die was then filled with a pre-mixed slurry. We permitted the fiber-matrix mixture to be under 30 kN of pressure. After being first increased to 160°C and maintained there for around 15-20 minutes, the temperature was then raised to (185–190)°C. After the die cooled to room temperature and the pressure was released, the composites were taken out of it.

2.3 Characterizations
2.3.1 Mechanical analysis

Tensile strength, flexural strength, hardness, and water absorption were all tested. For every test, five samples were examined, and the average outcomes were reported. Tensile tests were conducted in compliance with ASTM-D 638-01, utilizing a universal tensile machine with a crosshead speed of 5 mm/min [21]. The sample was 100 mm by 19 mm by 3 mm in size. The same testing equipment was utilized to conduct a static flexural test in compliance with ASTM D 790-00, using the same cross-head speed [22]. The specimens utilized had dimensions of 78 mm × 12.5 mm × 3 mm. The testing methods for calculating flexural property values utilizing universal testing equipment are shown in Figure 1. The specimens utilized had dimensions of 72 mm × 18 mm × 3 mm. The hardness of the composite was assessed using a shore hardness testing apparatus in the shore D scale.

2.3.2 Scanning electron microscopy (SEM)

The morphology of the composites was examined using scanning electron microscopy (JSM-6380 SEM, JEOL Ltd., Tokyo, Japan). The samples were freeze-fractured in liquid nitrogen and then sputter-coated with gold prior to examination.

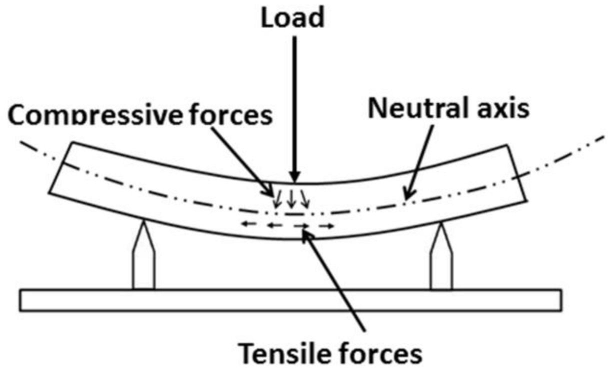

Fig.1. A schematic representation of a flexible test (three-point bending) that manufacturers of equipment utilize

2.3.3 Test for water absorption

The characteristics of natural fiber-reinforced composites' water absorption were evaluated by testing. For the purpose of the water absorption test, the samples were dried in an oven set to 50°C for 24 hours. Afterwards, they were placed in a desiccator to cool. As soon as they cool, the specimens are weighed and immersed in distilled water for 24 hours in compliance with ASTMD 570-99 [23]. Next, the final specimen weight was ascertained. The amount that the specimens' weight increased was calculated using the following equation:

$$\text{Water Absorption (\%)} = \frac{\text{Wet}_{\text{ weight}} - \text{Dry}_{\text{ weight}}}{\text{Dry}_{\text{ weight}}} \times 100\% \tag{1}$$

3. Results and Discussion

3.1 Tensile properties

The tensile properties of hybrid composites were determined using the stress-strain curve. The fluctuation in tensile properties as a function of fiber loading is seen in Figure 2. Tensile strength decreased with increasing fiber loading (Figure 2(a)). The tensile strength of composites with 5, 10, 15, and 20% fiber loading decreased by 23, 27, 31, and 33%, respectively, as compared to pure polypropylene. With increasing fiber loading, the weak interfacial area between the hydrophilic cellulose-based fiber and the hydrophobic matrix increases [24, 25]. Consequently, with time, the link between the matrix and fiber weakens [26]. Tensile strength consequently decreased over time. Similar trends were also observed by other studies [24, 27, 28]. Chemical alterations could lead to an improvement in fiber interaction. To properly interlock with the matrix, chemicals might activate hydroxyl groups or contribute new molecules. Benzoylation, alkali, acrylation, permanganate, silane, acetylation, maleated coupling agents, isocyanates, and sodium lauryl sulfate are a few examples of chemical treatments [29]. In the current investigation, sodium lauryl sulfate treatment was used to improve interfacial bonding.

The tensile modulus values for the polypropylene hybrid composites reinforced with banana fiber and coconut husk are displayed against the fiber loading in Figure 2(b). Tensile modulus increased with the amount of fiber loaded, as the figure illustrates, and the values were higher than those of virgin polypropylene. Tensile modulus rose by 17, 32, 24, and 15% for composites with 5, 10, 15, and 20% fiber loading, respectively, compared to virgin polypropylene. As the amount of fiber loading increased, the composite's stress-strain curve grew steeper and more brittle. Because of the partially split micro-spaces caused by inadequate interfacial bonding, stress cannot transfer between the fiber and the matrix. Increased fiber loading results in a greater degree of blockage, which raises the tensile modulus [30]. The polypropylene matrix was less rigid than the composites. But as you can see from Figure 2, with 15 and 20 wt% fiber loading, the tensile modulus marginally decreases. One possible reason for the difference in 15% and 20% fiber content composites above 10% fiber content composites could be poor filler matrix adhesion. Higher content of fibers can agglomerate, cause problems with matrix alignment, and function as defects [31].

The percentage of elongation at break for the hybrid composites varies with fiber loading, as seen in Figure 2(c). It is discovered that elongation at break is greatly decreased with the addition of fiber in the matrix because of the low elongation at break of the fibers relative to the polypropylene matrix. Yet, as the fiber loading increased from 5% to higher levels, the elongation at break only slightly increased due to the composites' reduced rigidity.

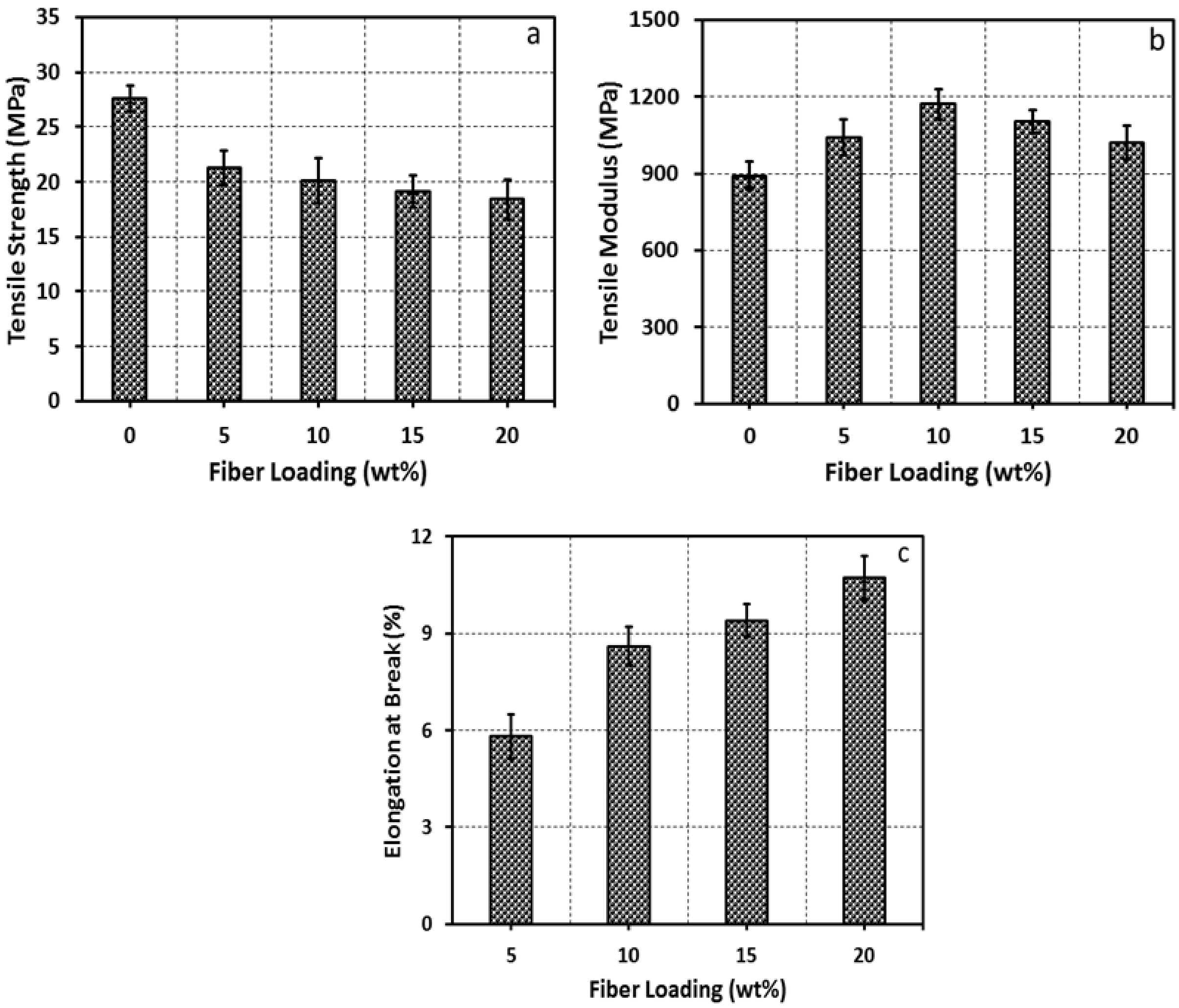

Fig.2. Variations in the following three parameters in response to fiber loading: (a) tensile strength, (b) tensile modulus, and (c) elongation at break (%)

Tensile strength, tensile modulus, and elongation at break are compared at different ratios of coconut husk fiber to banana fiber in Figure 3. Any composite's tensile strength is influenced by the internal structure and chemical makeup of the fiber. Due to its lower cellulose content (36–43%)

compared to banana fiber (48–71.08%), coconut husk has a lower tensile strength (105–593 MPa) than banana fiber (198–780 MPa). The 5:15 ratio of coconut husk and banana fibers was found to have greater tensile strength as compared to hybrid composites contacting those fibers at 10:10 and 15: 5 ratio (Figure 3(a)). This was due to the increased compatibility of the fibers with the PP matrix and better fiber dispersion in the matrix. Tensile strength, tensile modulus, and elongation at break are compared at different ratios of coconut husk fiber. The tensile modulus of the hybrid composite reinforced with coconut husk and banana fiber (at a ratio of 5:15) was higher than that of the other two composites (Figure 3(b)). Banana fiber has a tensile modulus of 6.6-25.6 GPa, while coconut husk has a tensile modulus of 2-8 GPa. Tensile modulus rises as a result of greater stress needs for the same deformation that arises from increasing banana fiber inclusion concentrations. Composites containing 25% coconut husk exhibited higher percentages of elongation at break compared to those containing 75% banana fiber (Figure 3c). The fact that banana fiber elongates less at break than coconut husk could be one cause.

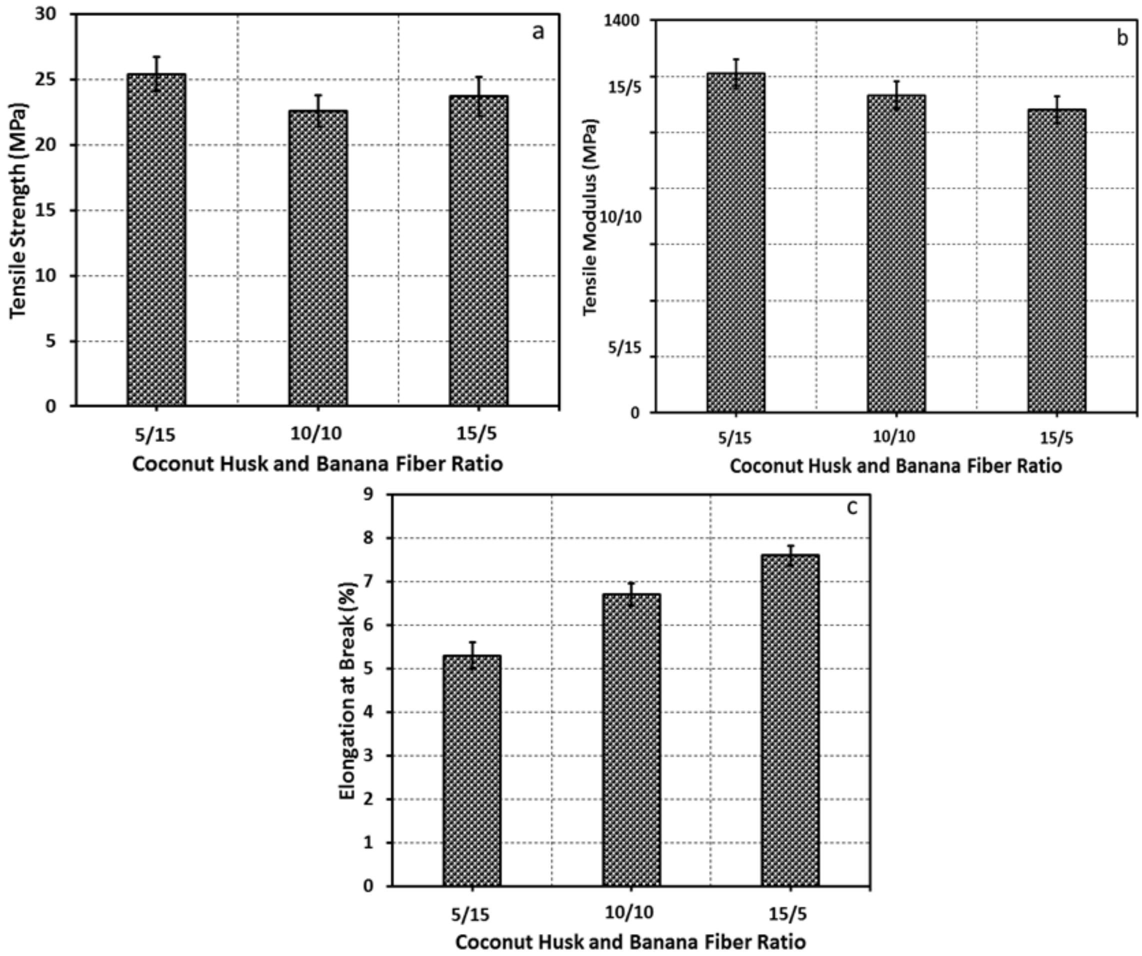

Fig.3. Variation for different fiber ratios at 10% fiber loading in terms of (a) tensile strength, (b) tensile modulus, and (c) elongation at break (%)

Coconut husk and banana fiber were chemically treated with 5% sodium lauryl sulfate to improve the adhesion between those fibers and polypropylene. The sodium lauryl sulfate treatment is expected to cause the interfibrillar region to become less dense and rigid, which will cause the fibrils to reorganize themselves more in the direction of tensile loading. Such a structure of the fibrils during stretching would result in better load sharing and hence increased stress generation in the fiber [30]. Two effects of a sodium lauryl sulfate treatment on the fiber are thought to be present: (a) an improvement in mechanical interlocking due to increased surface roughness; and (b) an increase in the number of possible reaction sites due to increased cellulose exposure on the fiber surface. One important factor in the mechanical properties is cellulose.

The mechanical properties get better as the cellulose concentration rises [32]. The effects of sodium lauryl sulfate (SLS) treatment on the tensile properties of hybrid composites reinforced with banana and coconut fiber are shown in Figure 4. The results of the chemical treatment are shown in Figure 4, where the tensile strength and tensile modulus increased by 17% and 5%, respectively. However, due to the related composites' higher stiffness following treatment with sodium lauryl sulfate, the percentage of elongation of break decreased by 28%.

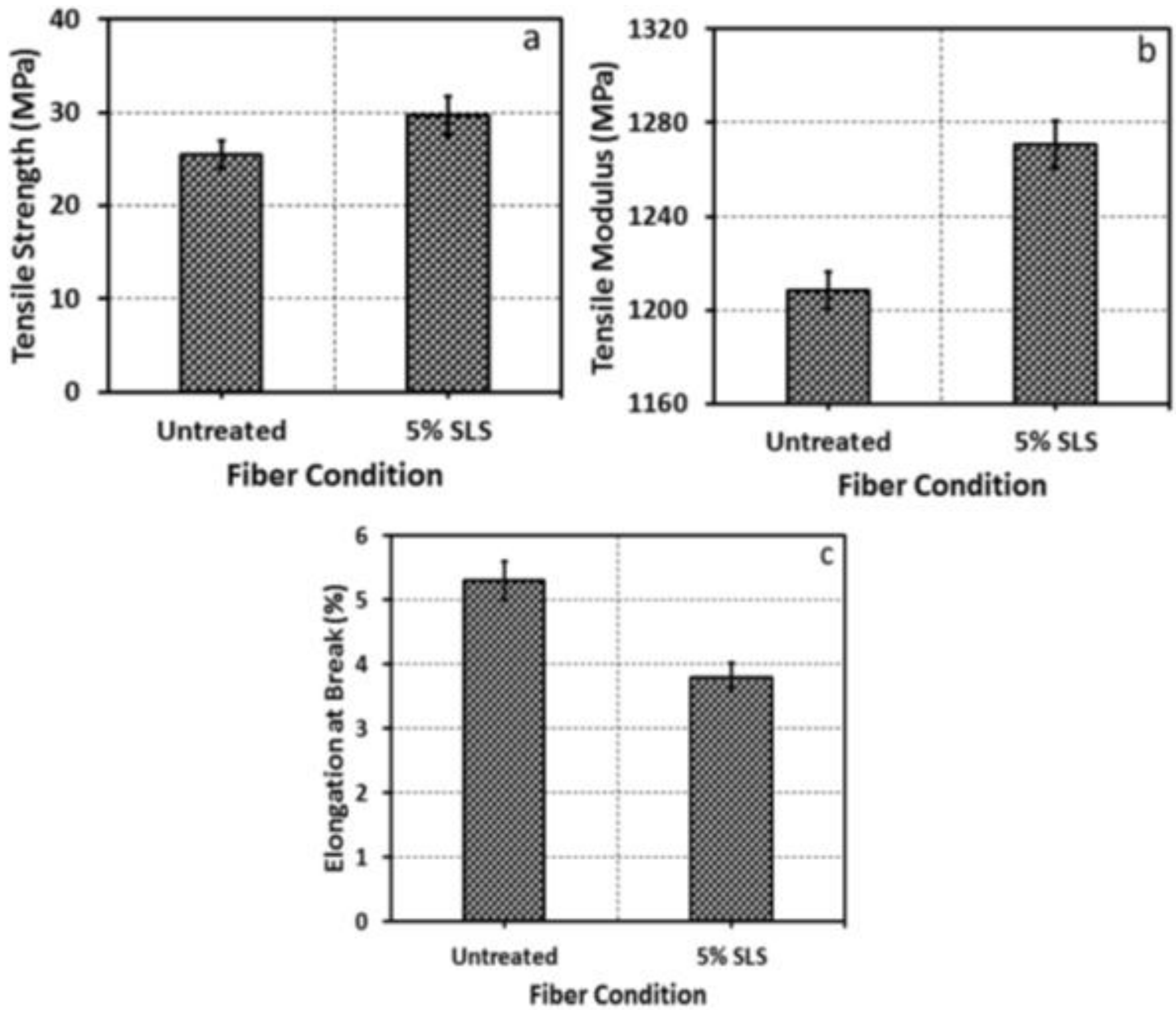

Fig. 4. Variation in the following parameters for sodium lauryl sulfate treatment: (a) tensile strength; (b) tensile modulus; and (c) elongation at break (%)

3.2 Flexural Properties

The flexural characteristics of samples with varying fiber contents were measured using the flexural load-extension curve and related formulae. The flexural strength and flexural modulus of raw hybrid polypropylene composites supplemented with banana fiber and coconut husk at different fiber loadings are shown in Figure 5. The flexural strength increased with the addition of 5% and 10% fiber to the polypropylene matrix (Figure 5(a)). This may be because the weak filler matrix adherence has been overcome by the filler and polymer chains' advantageous entanglement [33]. Flexural strength decreased little as fiber content rose to a higher value. Weak filler matrix adherence could be the reason for composites with 15% and 20% fiber content compared to those with 10% fiber content. As the amount of fiber rises, the fibers exhibit defects and become partially misaligned with the matrix [31]. The flexural modulus values of hybrid polypropylene composites reinforced with banana fiber and raw coconut husk at different fiber loadings are shown in Figure 5(b). Flexural strength increased along with up to a 10% increase in fiber loading. The composites have greater flexural strength values than the polypropylene matrix. Because the moduli of banana and coconut husk fiber are both high, a higher fiber concentration requires higher stress for the same deformation [34]. The insertion of the fiber (stiff coconut husk and banana fiber) into the soft polypropylene matrix resulted in an increase in the flexural modulus. The modulus values did not significantly vary between the fiber loadings of 15% and 20%.

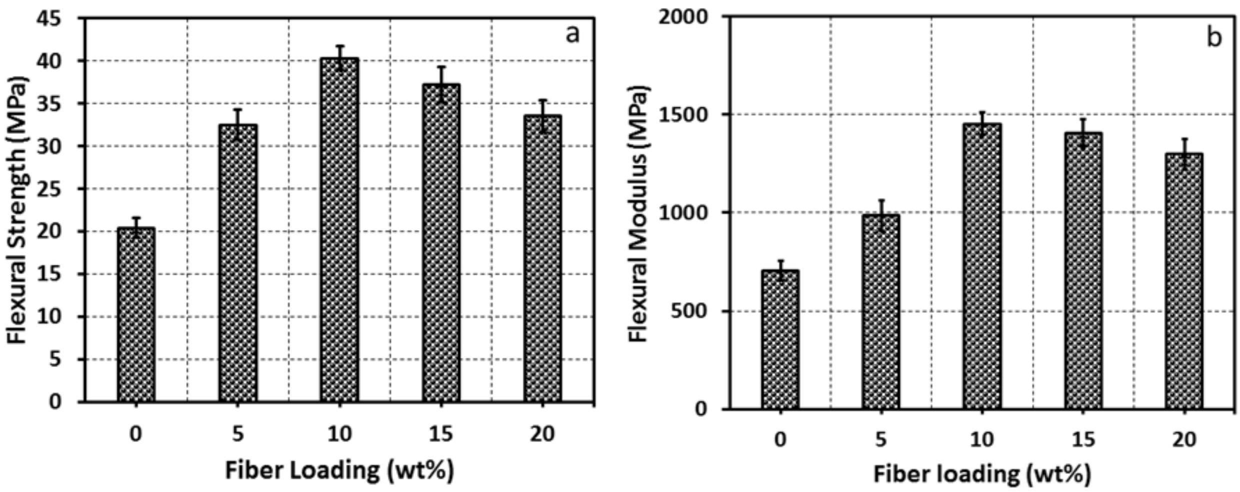

Fig. 5. Variations in the following two parameters in response to fiber loading: (a) flexural strength and (b) flexural modulus

Flexural strength and flexural modulus values for different fiber ratios are shown in Figure 6. Because the fibers were more compatible with the PP matrix and had better fiber dispersion in the matrix, it was demonstrated that the 5:15 ratio of coconut husk and banana fibers had superior flexural strength than hybrid composites contacting those fibers at 10:10 and 15:5 ratios (Figure 6a). In comparison to the other two composites, the hybrid composite with banana fiber and coconut husk reinforcement (at a 5:15 ratio) had a greater flexural modulus (Figure 6b). Banana fiber (48-71.08%) has a greater cellulose content than coconut husk (36-43%). Consequently, composites with a higher percentage of banana fiber displayed better flexural properties.

The effect of sodium lauryl sulfate (SLS) treatment on flexural properties is shown in Figure 7. With sodium lauryl sulfate treatment, there can be an improvement in the interfacial contact between the fiber and matrix. As a result, this increases both the effective surface area available for matrix interaction and the possibility of load transfer between the matrix and the reinforcing fibers [34]. This led to increases in flexural strength and flexural modulus of 4% and 1%, respectively.

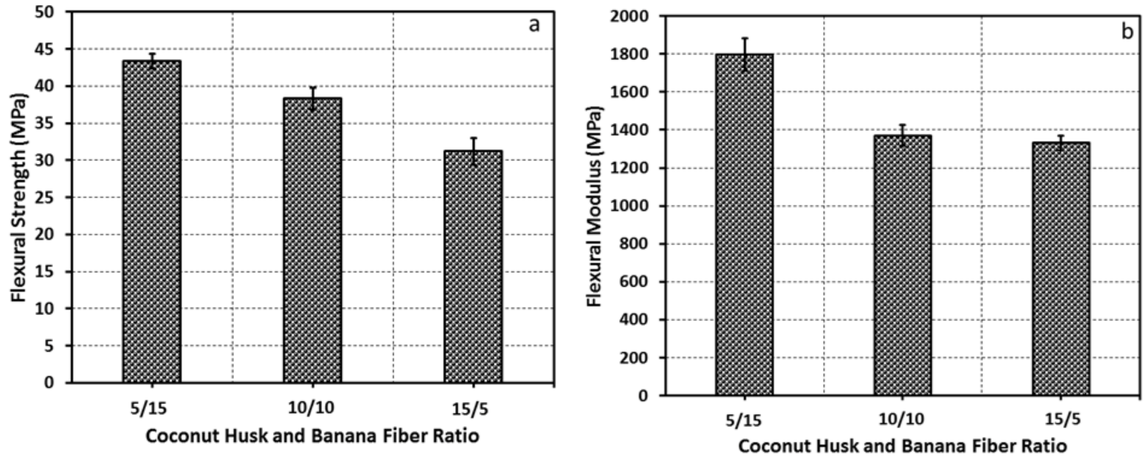

Fig. 6. Variation for different fiber ratios at 10% fiber loading in terms of (a) flexural strength, and (b) flexural modulus

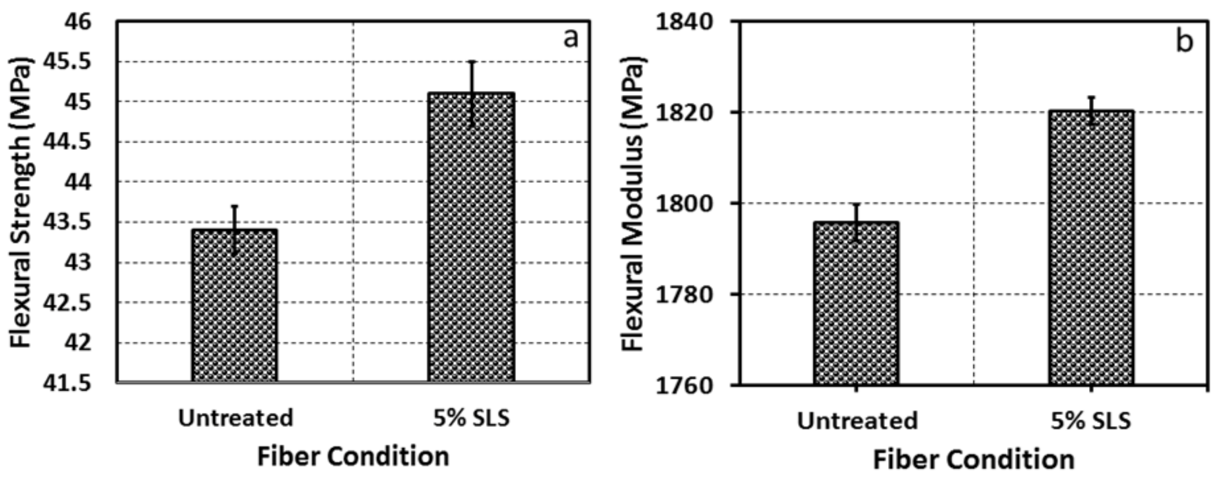

Fig. 7. Variation in the following parameters for sodium lauryl sulfate treatment: (a) flexural strength and (b) flexural modulus

3.3 Analyzing the hardness of the results

The hardness values of hybrid composites reinforced with banana and coconut husk fibers under fiber loading are shown in Figure 8(a). The polypropylene matrix that results is pliable. The presence of fiber makes the composite tougher. The hardness of a composite is influenced by the fiber dispersion inside the matrix [35]. Incorporating fiber also reduces the matrix's elasticity, making the composite more rigid [36, 37]. The hardness of hybrid composites increased progressively by 4, 6, 2, and 1% for composites with 5, 10, 15, and 20% fiber loading, respectively, in relation to virgin polypropylene. A little decrease in hardness was observed with an increase in fiber loading. When fiber loading increases at higher values, the formation of fiber agglomerates may cause a decrease in the hardness value. The fluctuation in fiber ratio for hardness is shown in Figure 8(b). The composite reinforced with a higher percentage of banana fiber has higher hardness values than the other composites. One possible explanation is that banana fiber has a higher cellulose content than coconut husk fiber. The cellulose content is the main factor responsible for the higher mechanical attributes, such as hardness. The cell structure collapses as a result of the cementing substance's devaluation brought on by the fiber's application of sodium lauryl sulfate treatment. This results in enhanced cellulose chain packing, void reduction, and void elimination in addition to better adhesion between the matrix and the fiber [38]. Thus, the hardness values of composites reinforced with sodium lauryl sulfate treated fibers were 2% higher than those of composites reinforced with raw fibers (Figure 8(c)).

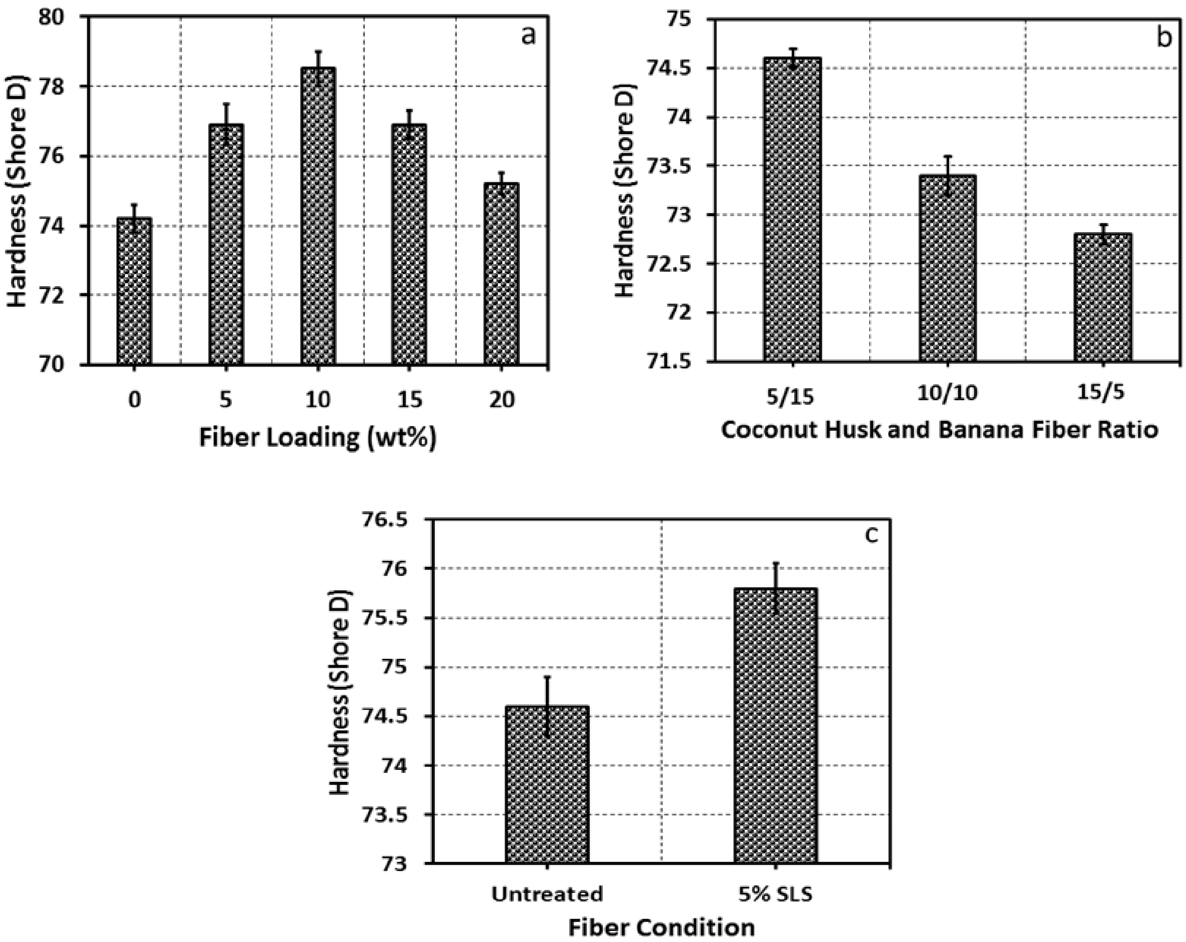

Fig. 8. Hardness variation in response to (a) fiber loading, (b) fiber ratio, and (c) treatment with sodium lauryl sulfate

3.4 Scanning Electron Microscopy (SEM) Analysis

SEM is a common technique for assessing the degree of adhesion between the polymer matrix and filler. An SEM was used to analyze the morphological characteristics of the tensile fracture surface of coconut husk and banana fiber in a 5:15 ratio, as well as the reinforcement composites that were treated with 5 wt% sodium lauryl sulfate at a 5/15 ratio. Figures 9(a)-(b) display the surface morphology of composites that were untreated (coconut husk and banana fiber in a 5:15 ratio) and composites that were treated with 5 wt% sodium lauryl sulfate. The interfacial characteristics of the untreated and treated composites differ significantly, as the photomicrographs make evident. It is clear from Figure 9(a) that the untreated composite has a lot of fiber pull-outs, broken fiber ends, and huge gaps between the fibers and the matrix during tensile load. The fibers also seem to be free from the polymer matrix. This suggests that the untreated fibers within the PP matrix have poor interfacial adhesion and insufficient wetting, most likely as a result of the significant surface energy differential between the fibers and the matrix. However, when a treated composite (Fig. 9(b)) fractures in a tensile test, the fibers are dragged out simultaneously with the PP matrix. Additionally, the SEM micrographs show that the inclusion of hybrid fibers treated with sodium lauryl sulfate significantly reduces the gaps between the fibers and the matrix. It appears that after being modified with a 5 wt% sodium lauryl sulfate solution, the fiber surface is becoming rougher once more with regularly spaced pin holes. This may be because fatty deposits, surface contaminants, and wax have been partially removed. Therefore, it was confirmed by the SEM photomicrographs that the addition of sodium lauryl sulfate successfully created a strong interfacial contact between the fibers and matrix in the treated composites, which was mirrored in their mechanical performances.

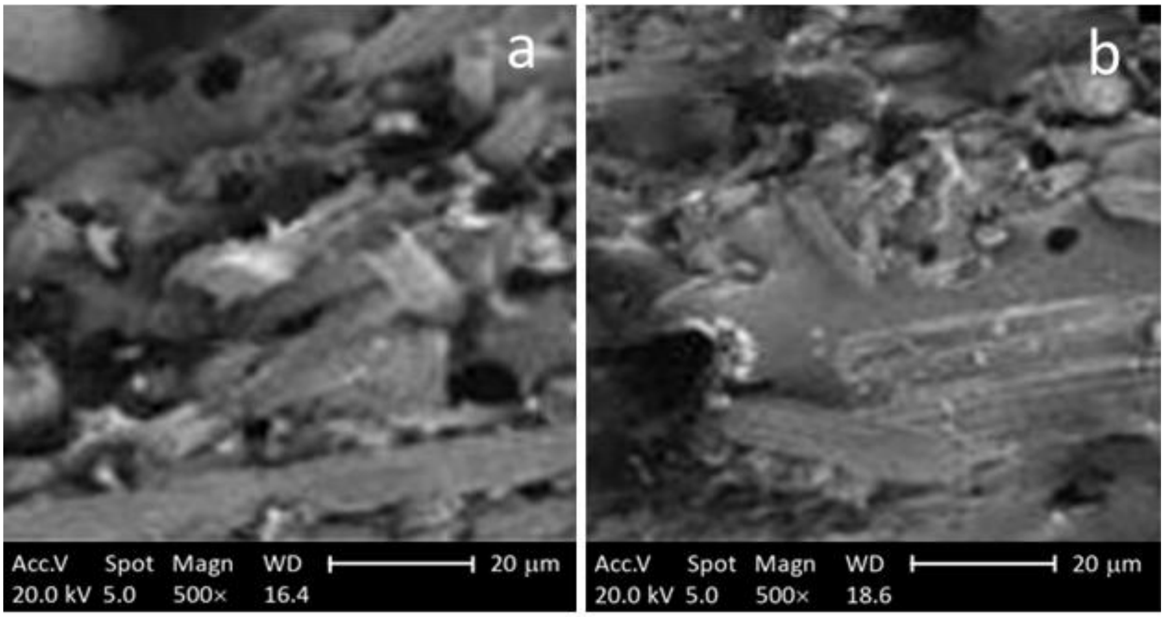

Fig. 9. Tensile fracture image of untreated (coconut husk and banana fiber in a 5:15 ratio) and treated (coconut husk and banana fiber in a 5:15 ratio) fiber-reinforced hybrid composite

3.5 Characteristics of water absorption

A water absorption test was conducted on polypropylene hybrid composites made of coconut husk and banana fiber, where the percentage of polypropylene is 80% and the total fiber content is 20%. Water absorption experiments were performed for an entire day on the hybrid composites with the fiber percentage changed to 15/5, 10/10, and 5/15 (coconut husk/banana fiber). The fundamental reason lignocellulosic materials are not used in engineering applications is their inclination to absorb moisture. Cellulosic fibers' absorption of moisture results in low strength and stiffness, dimensional changes, material swelling, and a loss in cell wall rigidity. The process of moisture sorption is significantly influenced by the surface shape of fibers, hemicellulose, non-crystalline cellulose, and lignin.

Choosing lignocellulosic materials requires a thorough understanding of the ability to approximate, and ability to overcome the water uptake behavior of natural fibers. Since cellulose is a natural component of natural fiber, it is hydrophilic, whereas polymers are hydrophobic. The hydroxyl group in the fiber affects a composite's capacity to absorb water. With an increase in composite fiber content, the number of hydroxyl groups in the composite increases. Therefore, water absorption increases (Figure 10(a)). The cellulose content of banana fiber is higher (71.08%) than that of coconut husk fiber (43%). Water absorption in composites rose as the ratio of banana fibers increased (Figure 10(b)). Following treatment with sodium lauryl sulfate, water absorption in treated fiber-reinforced composites decreased due to a decrease in the amount of hydroxyl groups (Figure 10(c)).

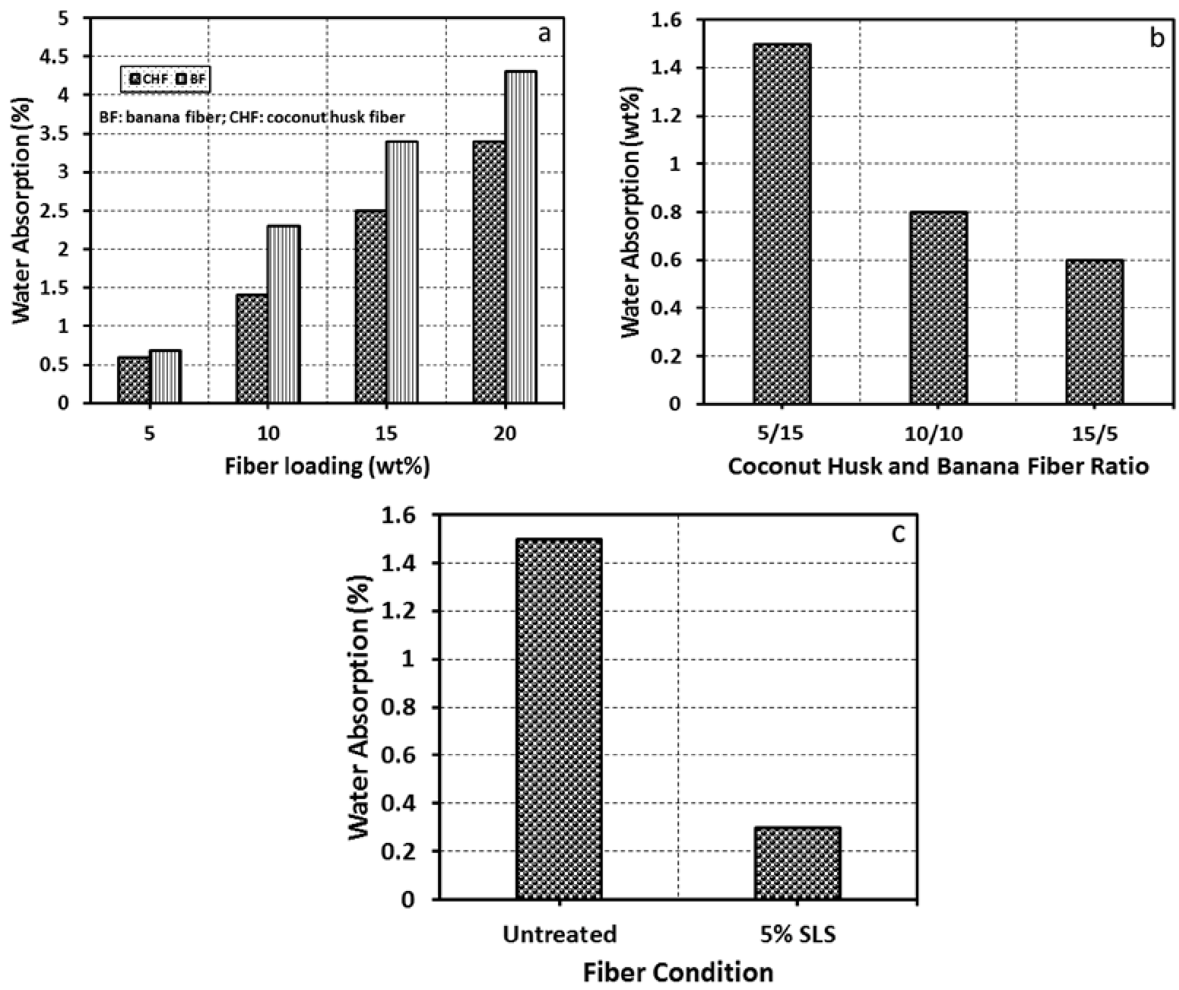

Fig. 10. Variation of water absorption against (a) fiber loading and (b) fiber ratio and (c) sodium lauryl sulfate treatment

4. Conclusions

In the current study, compression molding was used to create hybrid polypropylene composites reinforced with banana and coconut husk fibers. The main objective was to improve the mechanical qualities of polypropylene by reinforcing it with hybrid fibers. The mechanical properties of hybrid polypropylene composites reinforced with banana and coconut husk fibers improved with fiber loading, with the exception of tensile strength. On the other hand, it was demonstrated that every feature of the produced composites outperformed the properties of the polypropylene matrix. The mechanical characteristics of composites containing coconut husk and banana fiber in a 5:15 ratio outperformed those containing those fibers in a 10:10 or 15:5 ratio. The tensile strength, tensile modulus, flexural strength, flexural modulus, and hardness of the 5/15 ratio hybrid composites improved to 11%, 6%, 12%, 24%, and 2%, respectively, in comparison to the corresponding values of coconut husk and banana fiber at the 10/10 ratio hybrid composites. After being treated with sodium lauryl sulfate, raw banana and coconut husk fibers had mechanical properties that were better than those of raw fiber-reinforced composites. In comparison to untreated composites, the hybrid composites' tensile strength, tensile modulus, flexural strength, flexural modulus, and hardness increased to 17%, 5%, 4%, 1%, and 2%, respectively, when coconut husk and banana fiber were treated with 5 wt% sodium lauryl sulfate at a 5/15 ratio. Therefore, of all the composites that were produced, the fiber-reinforced hybrid composites that were treated with 5% sodium lauryl sulfate (SLS) demonstrated superior properties than the composites that were not treated.

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